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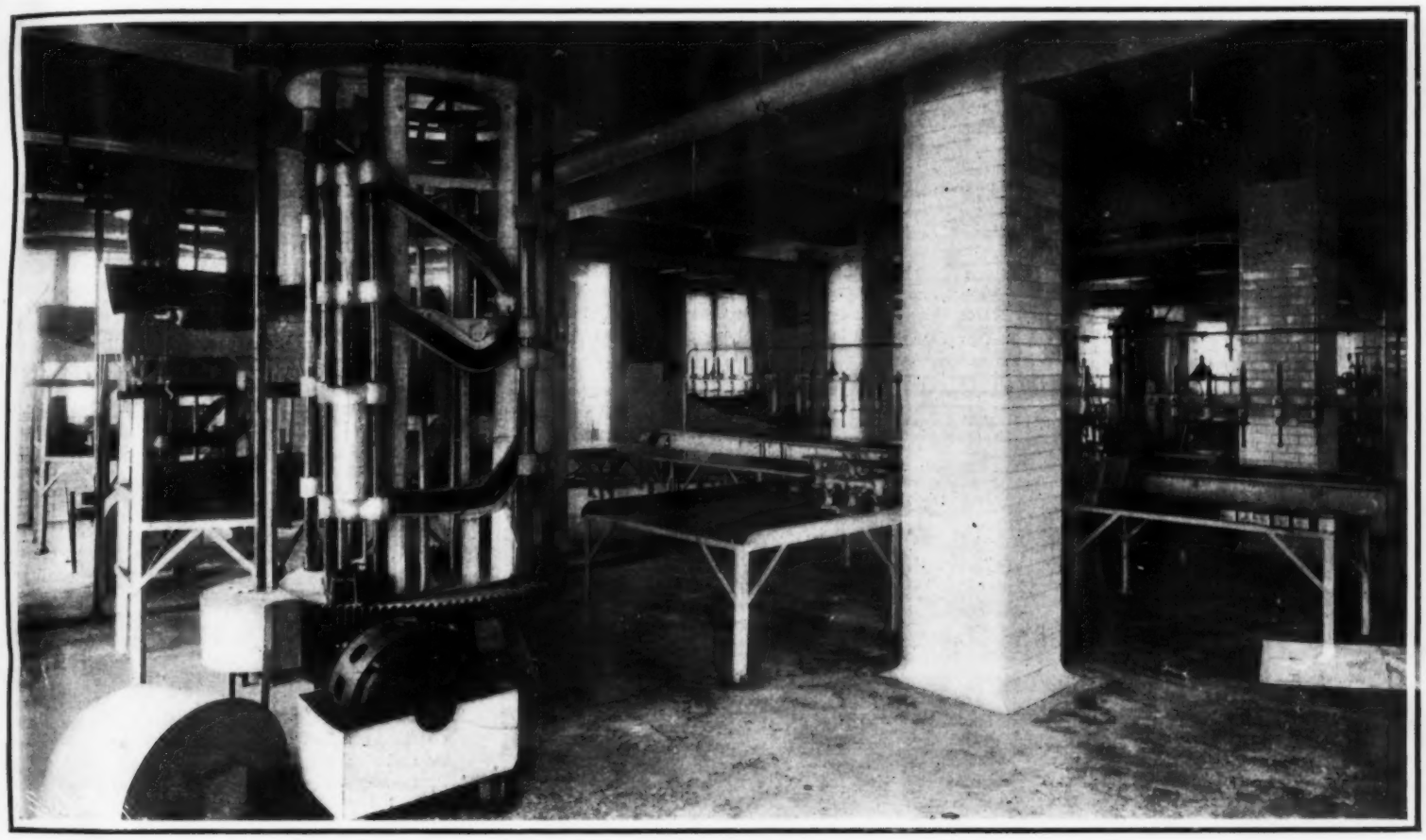
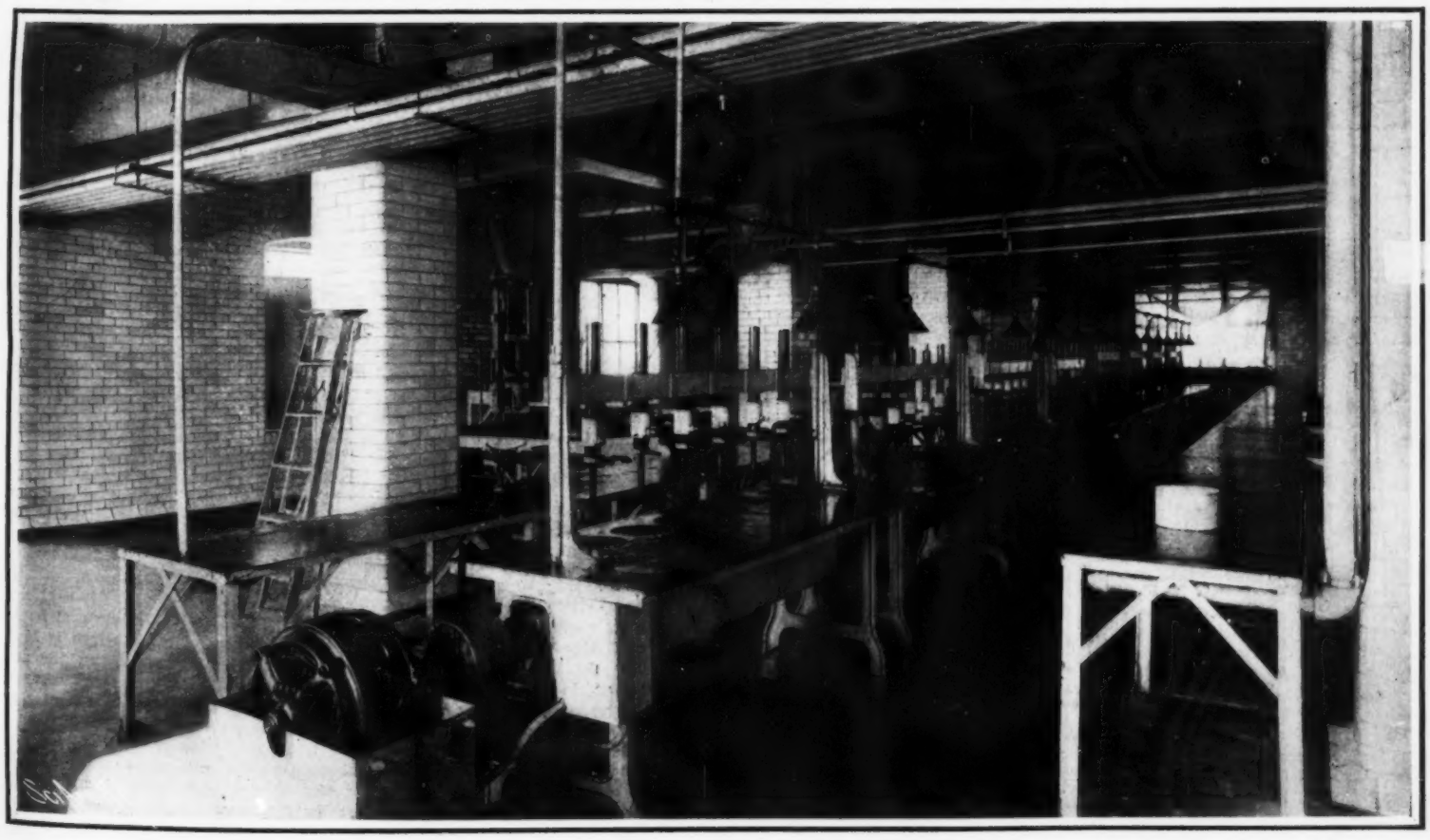


STUFFING MACHINES OPERATED BY ELECTRIC MOTORS AT ONE OF THE LARGE PACKING PLANTS.



DIRECT-CONNECTED CAPPING BENCHES OPERATED BY INDUCTION MOTORS.

ELECTRICITY IN THE PACKING PLANT.

ELECTRICITY IN THE PACKING PLANT.

SOME NEW LABOR-SAVING DEVICES.

BY FRANK C. PERKINS.

IN the Chicago meat packing establishments electricity is employed very extensively and to great advantage, resulting not only in increased economy, but also in cleanliness, as the old system of shafting, belting, and pulleys resulted not only in loss of power, but gathered dirt on the many exposed surfaces.

Nearly 10,000 horse-power of electrical energy is utilized in the plants of two of the largest companies, the motors having a capacity of from 1 horse-power upward and driving various machines, including rockers, crimpers, plotters, and other devices technically known as crutches, neutralizers, splitters, strippers, and scores of other machines too numerous to mention in detail.

The accompanying illustrations show some of these electrically operated machines, including one or two 7½-horse-power motors and four 5-horse-power induction motors direct connected to stuffing machines operating at a speed of 1,130 revolutions per minute.

In the nine-story electrically operated kitchen of one Chicago plant electric energy is employed for preparing the potted tongue, boneless chicken, and canned corned beef as well as the other delicacies shipped all over the world. From the adjoining slaughter house the meat is brought in the above-mentioned building after being cut into suitable lengths and thoroughly cleansed, and is then transferred in buckets on trolleys to the cooking room in which there is absolute cleanliness. The walls are faced with white enameled brick, the ceilings and floors are of concrete, the window sashes shine with polished metal, and there is not a piece of wood either in this or the other rooms to be described.

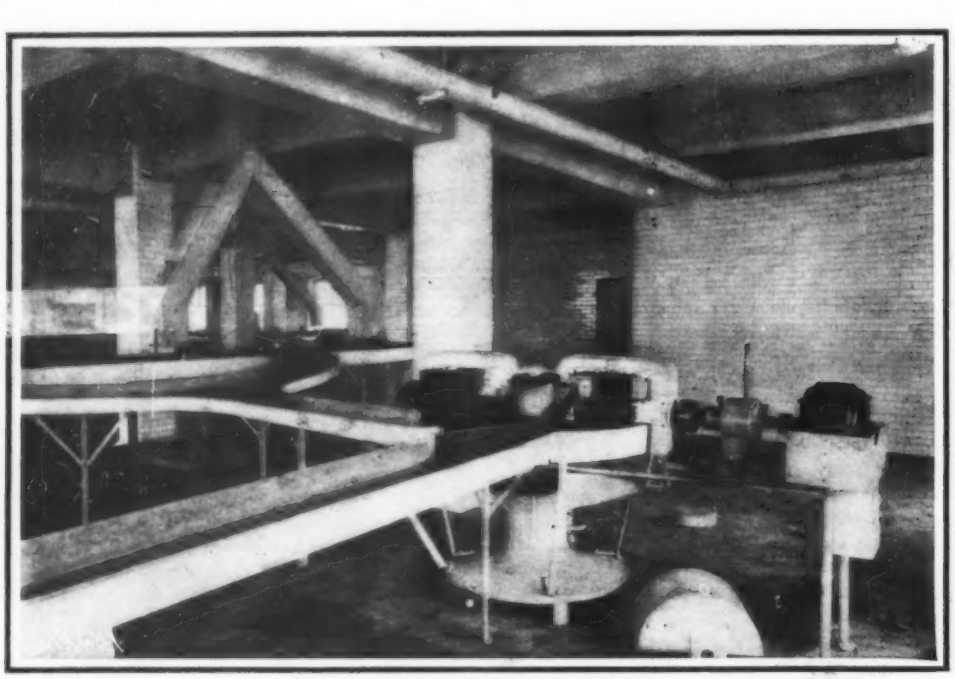
The meat is then sent from the cooking room on enameled conveyers to large white tables in the trimming room on the eighth floor, where it is put in shape for the tins. Flesh representing over two hundred and fifty cattle can be trimmed here in an hour, with the aid of five meat choppers, each direct connected to a 2-horse-power motor.

The corned beef is put up in the square-canning room, where four stuffing machines, each driven by a 5-horse-power motor, and three capping benches, each taking its power from a 2-horse-power motor, constitute the principal apparatus used. The round-canning room is filled with stuffing machines and capping-benches driven in the same manner as those above described and both are supplied with vacuum pans, enabling the cans to be sealed in vacuum. The six pumps installed for this service in an adjoining room are all driven by belting from one 40-horse-power motor.

The various conveyers used in these rooms have each one ½-horse-power motor direct connected. All of the motors operate on alternating current and are of the so-called "squirrel-cage" induction type. They offer especial advantages for the service, being very simple in construction and easily kept clean.

The shipping is done from the third floor and on the first and second floors are the offices, electric generating plant and refrigerating machines, and here also the walls and ceilings are covered with white enamel and throw into sharp contrast the glistening black paint and highly polished steel of the machinery. On all of the floors there are numerous windows, and with the absence of overhead gear of any kind, good light and ventilation are secured, making the entire plant, with apparatus such as that above described, a veritable triumph of sanitation. All tables, trucks, and instruments are in keeping with the rest of the establishment, there being nothing that will absorb moisture, and every fixed piece stands on legs high above the floor, enabling the latter to be thoroughly flushed at the close of each day.

Every effort is made to manufacture large quantities at the minimum of expense, with good refrigeration and utilization of all "waste" material and the utilization of the very best mechanical methods and appliances. It is here that motor-drive has been taken up with notable results, particularly in the conversion of "waste" into dollars; for were it not for the so-called "by-products" it is claimed by the packers that there would be, under present conditions of trade, not only scant profit, but an actual loss in the handling of meats from live animals. Some years ago the only materials of this kind to which the packer gave any thought were hides and tallow. Other manufacturers in the vicinity, such as glue makers, bought certain parts of the waste; but no really effective utilization of it was made until the meat-men themselves had their attention aroused to the possibilities of this branch of the business. The manufacture of soap was first taken up, then glue, then fertilizers. Hair which was formerly thrown away, except for small quantities used by plasterers, is now dried and sold for many purposes. Horns and hoofs form valuable articles of commerce, being used for combs, handles, buttons, and ornaments by the score, including excellent imitations of costly materials, and electric energy serves in producing this material cheaply. Dried blood, ground bone, waste tissues and fibers, when made up into fertilizer mixtures, retail at many dollars per ton. Cartilage and related substances reappear as glue. The choicest of fats, once indiscriminately classed as tallow, or at best used for lard, form the chief element in making butterine or oleomargarine, and the residue from this fat is refined into stearine, an element of chewing gum. Electric motors are employed in each process through which any part of the animal passes until its last vestige has disappeared in the fertilizer house or glue factory. There are electric meat-hoists, metal sharpeners, rip-saws, horn saws, and throw-outs in the butcher-shop, and electrically driven rippers, cleaners, stuffers, washers, salters, and sewing machines in the sausage plant. In the butterine factory there are electrically operated renovators, box churns, suet choppers, and butter workers. In the soap factory may be seen electric presses, mills, oil circulators, and molding machines and electric dryers, washers, compressors, guano crushers, and screens in the fertilizer works, with electric dryers, grinders, and reels in the glue establishment and electric barrel-headers, hoopers, borers, washers, and scourers in the cooperage plant. In fact the list of electrically driven machines employed could be extended indefinitely.



ELECTRICALLY-DRIVEN MEAT CHOPPERS.

BRIQUETTES MADE WITH TAR.

SO MANY inquiries as to the newly patented Shedlock process of manufacturing briquettes with tar have reached Consul Lorin A. Lathrop, at Cardiff, from different parts of the United States that he has thought well to send all information that is to be obtained at the moment. The consul writes:

The process has been patented in all the coal-producing countries of the world. The United States patents were taken out in 1904 and 1907, respectively, and are numbered 774,705 and 857,417. The patentee has prepared a statement as follows:

Shedlock's patented process and apparatus for the manufacture of briquettes ("Castle" brand) consists in a combination of tar distillation and the consolidation of small particles of coal (waste) of all kinds, into dense blocks of fuel, smokeless in character and possessing high calorific value. The process consists in first effecting a perfect mixture of the small particles of coal with any suitable tar, whereby each particle is covered by a thin film of tar. The quantity of tar used is entirely dependent on the nature of the coal, in any case not exceeding 6 per cent of the whole. The prepared materials are then automatically and continuously fed into and passed in thin layers through a heated apparatus, whereby the fuel materials are raised to such a temperature as to volatilize and separate the oils from the tar, which are automatically withdrawn from the apparatus and condensed, thereby providing a by-product of equal or even greater value than the tar used.

The thin film of pitch deposited on each particle of coal forms the agglutinant, which, when the materials are subjected to the necessary pressure, causes their consolidation into blocks more homogeneous and harder than the coal from which the small or waste coal was originally obtained. The fuel materials are automatically passed from the heating apparatus in which they were treated for the removal of their volatiles directly into an agitator, thence into the compressing apparatus, from which the fuel blocks issue in such a condition that they may at once be loaded into trucks or otherwise disposed of.

The *rationale* of the process is embodied in the fact that the smaller quantity and nature of the pitch used than that in the present system of making fuel briquettes conduce not only to the production of smokeless fuel, but the pitch so formed in the materials is of such a dry and hard character that it has no tendency to expand and disintegrate the fuel when subjected to the intense heat of a furnace fire, but, on the contrary, in combustion opens into hard coke-like masses with clefts, thereby presenting large surface for oxidation and production of intense heat. The "Castle" fuel has been subjected to exhaustive trials in the firing of locomotive and other furnaces where a solid fire and intense heat is a desideratum, and it has proved itself an ideal fuel, smokeless and of high calorific power. It has also proved itself eminently adapted for shipment to and storage in tropical climates, having passed successfully through all the tests to which fuel under such conditions is subjected.

The "Castle" fuel possesses the further and important advantage that its cost of manufacture is 15 to 20 per cent less than other systems of making artificial fuel. Briquettes of all sizes (from a few ounces to 16 or 20 pounds) can be produced by the apparatus, the smaller sizes being eminently adapted for domestic and general manufacturing purposes, the larger sizes for shipment abroad and storage as a standby in the event of strikes or dislocation of supplies, for marine and railway purposes, as no loss or deterioration of this fuel takes place, however long it may be exposed to atmospheric changes.

The cost of a complete plant to manufacture 500 tons of "Castle" fuel (briquettes about 16 pounds

each) is about £10,000 ($48,665)—a smaller output per day in accordance with the weight of the briquette.

No special machinery is absolutely necessary for the manufacture of these tar briquettes. It has been found in practice, however, that a more perfect briquette is formed with a heavier impression than can be obtained from a rotary press of the Belgian type or other existing machines. Doctor Shedlock now employs a rammer working on a die with a combination of hydraulic and mechanical power. He has patented, or is about to patent, this rammer. His interests in the patent have been sold.

HEAT-BALANCING IN LOCOMOTIVES.*

STUDIES IN COMBUSTION AND RADIATION.

BY LAWFORD H. FRY.

THREE losses with the heat usefully employed in the production of steam must account for all of the heat contained in the coal, and complete the heat balance.

(1) Loss of Heat in the Products of Combustion.—The products of combustion consist of certain dry gases, and in addition to these a considerable amount of water vapor from the water of combustion of hydrogen in the coal, and from the moisture in the coal and in the air. There is also a trace of sulphuric acid from the combustion of the sulphur. In the St. Louis tests the water of combustion with the sulphuric acid amounted to 0.40 pound per pound of coal burned. The moisture in the coal was always in the neighborhood of 1 per cent, and, therefore, the water vapor produced, per pound of coal burned, may be taken with sufficient accuracy as 0.41 pound, as fired. In addition to this vapor, the moisture in the air admitted for combustion must be taken into account. The percentage of moisture in the air can be determined from the wet and dry thermometer readings which were taken. The weight of the dry gaseous products of combustion per pound of coal burned is 0.54 pound more than the weight of air supplied per pound of coal. The amount of heat carried off by the products of combustion depends on the weights of dry gas and water vapor produced per pound of coal burned; on the temperature at which they escape to the smoke-box; and on their specific heat.

(2) Loss of Heat by External Radiation.—This loss was not measured in the St. Louis tests. It seems, however, permissible to assume that the loss by external radiation is 5 per cent of the heat utilized by the boiler in evaporation.

(3) Loss by Imperfect Combustion.—This falls under two heads:

(i) Loss by production of carbon monoxide.

(ii) Loss by escape of unburnt coal at chimney and ashpan.

(i) The first-mentioned loss can be calculated from the analysis of the flue gases. There is a general tendency for the loss by CO to increase as the rate of combustion is increased, but except in Series 100 there is no very serious loss on this score. In Series 100 one individual test shows a loss of 16.33 per cent by CO. This is due to the rapidity with which the air supply falls off as the rate of combustion is increased. Evidently the difficulty of getting air to the fire limited the power of this boiler, and prevented the rate of combustion being pushed above 90 pounds of coal per square foot per hour.

(ii) The loss of heat by the escape of unburnt coal is the most important loss in the heat balance when the boiler is working at full power. The coal escapes unburnt in three ways:

As sparks; into the ashpan; as unconsumed gas in the products of combustion, entailing a secondary loss by the sensible heat of the unconsumed gas in the smoke-box.

As the necessary observations were not taken, it is not possible in the present tests to determine the separate value of each of the four items of the loss by unburnt coal, but the total amount of heat lost can be determined by a method which is illustrated by the following example:

In Test 8,006 there is known—

	Per cent.
Heat of evaporation	47.20
Heat lost by external radiation	2.36
Heat lost in the production of CO	0.70
	50.26
This leaves as the loss to be divided between the products of combustion and unburnt coal	49.74
	100.00

The heat lost in this test in the products of combustion was 19.3 per cent of the total heat of the coal actually burned. Now if, for example, 25 per cent of the coal were to escape unburnt, the loss in the products of combustion would apply only on the remaining 75 per cent actually burned, and would be 0.75 × 19.3, or 14.5 per cent of the heat of all coal fired. Consequently, if P is the percentage of heat lost by coal escaping unburnt, the loss in the products of combustion is 19.3 [(100 — P)/ 100] per cent of the total coal fired, or calling this P we have $P_1 = 19.3$ [(100 — P)/ 100], and $P_1 + P = 49.74$, whence, by simple algebra, it is found that P, the loss by unburnt coal, is 37.7 per cent.

The general results of all tests is that the efficiency of the absorption of the heat is practically independent of the rates of combustion and evaporation, so that under all conditions of working the heating surface absorbs about 81 per cent of the heat produced by combustion. Approximately, the same figure is obtained for all four boilers, although they vary considerably as regards design and ratio of heating surface to grate area. The figures show that the efficiency of the boiler, as a whole, is mainly determined by the efficiency of the combustion, which falls rapidly as the rate of combustion is increased.

Although the smoke-box temperature at which the products of combustion escape increases as the rate of combustion increases, the percentage of the coal heat carried away by these gases is reduced. This is due to the reduction of the weight of gas produced per pound of coal burned. When the rate of firing was increased from 30 pounds to 130 pounds per square foot of grate, the weight of the products of combustion was reduced from about 18 pounds to about 8.5 pounds per pound of coal fired. For complete combustion about 11 pounds of air are required, so that when the boiler was forced it was not possible to get enough air through the fire to burn all of the coal fired. The figures obtained show that the locomotive of Series 100 is particularly choked for want of air. The author learned with much interest, after writing the foregoing, that since the tests the Pennsylvania Railroad has increased the area of the air inlets in the ashpan of this locomotive, with the result that it steams much more freely and efficiently.

* From a paper read before the Institution of Mechanical Engineers, dealing with experiments made on the locomotive testing plant of the Pennsylvania Railroad at the St. Louis Exhibition, and later at the Altoona (Pa.) shops.

THE PHENOMENON OF TRIBO-LUMINESCENCE.

By the PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

IN a paper presented to the Académie des Sciences, M. Adrien Karl brings out some points regarding the phenomenon which some bodies possess of showing light when they are broken or rubbed, this effect being known as tribo-luminescence.

This phenomenon appears to be a rather general property of solids. Many of the mineral substances which do not seem to possess this property would be seen to have it, provided the eye were kept beforehand in the dark so as to become more sensitive to such effects. In this way the author was able to observe the tribo-luminescence of oxide of thorium, titanic and tungstic acids, zirconia, cadmium sulphide, etc. Another cause of non-observation is the resistance to crushing. This is the case with natural silica, which becomes very tribo-luminescent when it is scratched by means of an emery wheel. Another cause is the great fragility of the bodies. This may be overcome by plunging the body in question in liquid air, when it is hardened and the phenomenon can be observed. But there are bodies which do not show this phenomenon, no matter in what condition they may be placed. The author recognizes, in the same way as for the cases elucidated by M. Urbain for phosphorescence, that in order to produce these effects we must have the co-existence of a diluting body and a phosphorescent body or phosphorogen. In phosphorescent bodies, in fact, M. Urbain shows that in general these consist of a very small amount of the phosphorogen, diluted in a large quantity of another body. In like manner, in order to produce tribo-luminescence we must have a large proportion of a diluting body and small quantities of an appropriate exciting substance (tribo-luminogen). It is observed that pure substances are not tribo-luminescent. A system which shows such property almost always keeps it when it is engaged under different chemical forms. Thus manganiferous oxide of zinc which is tribo-luminescent will give products which are able to produce this effect when it is transformed into nitrate or sulphate. However, the fluoride product does not produce it. A systematic study of certain series of mixtures shows that there is a maximum of brightness and this corresponds to a certain quantity of the constituents. This quantity differs greatly for different bodies, as follows: TuO_2ZnS, maximum with 1/1,000 part of tungsten; MnZnS, 1/800 of manganese; PbZnS, 1/500 of lead; UZnS, 1/200 of uranium. Comparing this with the values which are found in the case of phosphoresence in the same bodies, we find that the proportions for the maxima are quite different. This point is of interest as we see that there is no doubt a distinct action of the exciting body for each of these cases. The sensitiveness of the tribo-luminescent phenomenon is very high for certain diluting bodies. A fractionation of six months upon ten fractions of nitrate of zinc was found to weaken considerably the tribo-luminescent properties of the sulphide which it contained, but it did not cause these to disappear entirely. The oxide prepared with the same fraction no longer showed the phenomenon. In general, a purification which is carried far enough enables us to see a total extinction. The author observed this fact especially in the case of an acetate of uranium which showed a distinct effect at first. Referring to the above figures for the maximum effect, it is found that such a maximum must not be exceeded, and that increasing quantities of the exciting substance will on the contrary cut down the luminous effect. In such case we must add more of the diluting substance so as to produce the highest effect. The author specially observed mixtures in which the diluting substance was sulphide or oxide of zinc, and where the exciting body was varied. To give the intimate mixture of these parts any of the usual means can be used, such as the simultaneous precipitation where this is possible. He then raised the zinc sulphide to a high heat in a Mermet furnace in a current of hydrogen sulphide. As to the oxides, they are heated to a less degree in a Leclerc furnace, or else in a muffle furnace. The different exciting bodies were silver, lead, tungsten, copper, uranium, iron, etc. It is found that the color of the light varies with the exciting body. For instance, it is blue with lead and orange with manganese. The diluting body also affects the color. Thus in the system (TiO_2, ZnO), the light is a pale violet; with (TiO_2, ZnS) it is a deep green. Another point is that the color of the light is not necessarily the same as for the phosphorescence of the same mixtures.

Metatolyl hydrazide acid carbonate, $CH_3 \cdot C_6H_4 \cdot NH \cdot CONH_2$, which has been in use for some years as an antipyretic, is confirmed as possessing valuable properties. It is very stable, being undecomposed in the system, so that its effects are lasting and do not give rise to cyanosis and collapse. It has a marked diaphoretic action. In fevers, doses of 3 to 4 grains reduce the temperature in thirty minutes, the minimum being attained in three hours. Afterward the rise in temperature is slowly resumed. In the case of very high temperatures, such as occur in enteric fever and pneumonia, a single dose rarely reduces the temperature; in these cases small doses of 2 to 3 grains should be given every two hours, but not exceeding 9 to 12 grains in twenty-four hours. Maretine is chiefly eliminated unaltered in the urine, and perspiration; it imparts a greenish-yellow tint to the former, which then reduces Fehling's solution. It does not depress the heart; on the contrary it has a marked tonic action on the cardiac system, which renders if of special value in many febrile cases. The lowering of the temperature by small doses is not abrupt, but slow and gradual, and is prolonged for three to six hours. It is specially valuable in enteric fever. In addition to this it has given good results in the treatment of acute and chronic affections of the respiratory system, diminishing the number of inspirations and increasing their depth, but it is inefficacious in dyspnœa due to cardiac trouble.—G. Florio and G. Zambelli (Il Morgagni, Nouveaux Remèdes, 1907, 22, 463).

THE DUDDELL THERMO-GALVANOMETER.*

A DEVICE FOR MEASURING EXTREMELY SMALL CURRENTS.

BY A. FREDERICK COLLINS.

IN previous articles published in the SCIENTIFIC AMERICAN the writer described a number of instruments for measuring the frequency of electric oscillations in, and the length of the electric waves emitted by the sending aerial of a wireless telegraph transmitter.

An instrument for measuring the extremely small currents and potential differences to a high degree of accuracy in the aerial wire of a wireless receptor has recently been devised by the well-known British physicist, W. Duddell, and this has been put on the market by the Cambridge Scientific Instrument Company, Ltd., of Cambridge, England. The device in question is a thermo-galvanometer and different from instruments of the electro-magnetic type, where the high resistance and inductance of the coils often prevent their use in so far as accurately measuring small alternating currents is concerned, as for instance, those set up in aerial wire system of a wireless receptor, the Duddell contrivance has practically no inductance and no capacity, and can in consequence be used for oscillations of any frequency even up to 12,000 cycles per second, and currents as small as 20 micro-amperes can as readily be measured by it. It is also far superior to electrostatic instruments, for as at present constructed they are not very suitable for the determination of very small currents unless a large potential difference is available. Again, the thermo-galvanometer can be used with equally accurate results on continuous and alternating currents alike, and hence it is possible to standardize it by continuous current, and subsequently use it without error for currents of any frequency or wave form. Owing to this marvelous flexibility, the new instrument provides operators and investigators with means the lack of which has been keenly felt in the past. The thermo-galvanometer comprises chiefly a resistance which is heated by the current to be measured, the heat thus produced falling directly upon the thermo-junction of a Boys radio-micrometer. The latter device, it may be explained, is formed by two bars of antimony and bismuth, or of their alloys soldered side by side to the end of a minute strip of copper foil, which is provided for the purpose of receiving the radiation that is to be measured. The absorption of the heat by the copper strip produces an electric current, and the circuit through which this flows being suspended in a magnetic field is instantly deflected to a degree dependent on the intensity of the radiation or of the current generated at the thermo-electric junction.

In the Duddell instrument the rise in temperature of the lower junction of the thermo-couple produces similarly a current in the loop, which is deflected by the magnetic field, but in this case it is against the torsion of a quartz fiber; hence the galvanometer is dead-beat, and is not affected by magnetic fields. The principle of the thermo-galvanometer is shown diagrammatically in Fig. 2. In the field between the pole pieces *N S* of a permanent magnet is suspended by a quartz fiber *Q* a single turn or loop of wire *L*, to the lower ends of which is attached the thermo-couple *Bi* (bismuth) and *Sb* (antimony). Above the loop is a glass stem *G*, in which is mounted the mirror *M*.

Below the lower junction of the thermo-couple is fixed the heating resistance or "heater," as it is called, one end of which is connected to the frame of the instrument to eliminate possible electrostatic influences. The current to be measured passes through this heater, raising its temperature; this process causes the lower junction of the thermo-couple to rise in temperature above the upper one, setting up a current in the loop *L*, which is then deflected by the magnetic field against the torsion of the quartz fiber *Q* as described.

The deflections of the mirror are practically proportional to the square of the current when the heater is immediately under the junction. The degree of sensitivity of the thermo-galvanometer depends on the resistance of the heater and on the distance of the latter from the thermo-junction. The heaters, of which two are supplied with each instrument, being respectively 5 to 10 ohms and 100 ohms, are provided with small protecting cases having contact rings, and these may be quickly changed when the exigencies of the tests require that the sensitiveness of the galvanometer should be altered.

An adjusting screw is arranged under and fixed to the heater, so that its distance from the thermo-couple can be varied within certain limits, and by utilizing this means small variations in the sensibility of the instrument can be made without changing the heaters or the shunts that accompany the device. It should be stated that the shunts furnished are of value only

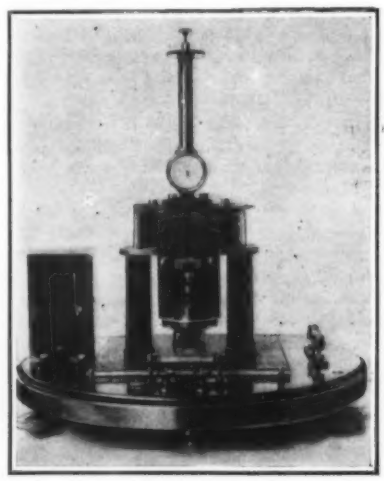


FIG. 1.—DUDDELL THERMO-ELECTRIC GALVANOMETER FOR MEASURING OSCILLATIONS IN RECEIVING AERIALS.

in measuring alternating currents having a frequency of less than 1,000 cycles per second and for direct currents; but where measurements are made of higher frequency oscillations, such as those set in the receiving aerial of a wireless telegraph receptor, the ratio in which the current will divide between the circuits of the instrument and the shunt is not fixed, and consequently very uncertain.

The reflecting mirror *M* has a plane surface, but a lens is supplied which projects an image on the scale at a distance of 1,000 millimeters when used with the ordinary galvanometer lamp and scale.

From tables showing the approximate sensitivities with the ordinary resistances furnished with the instrument, the following results were obtained: With a heater having a resistance of 927 ohms, the current required to give a deflection of 250 millimeters on the scale, at a distance of 1,000 millimeters, was 117 micro-amperes, while the potential difference

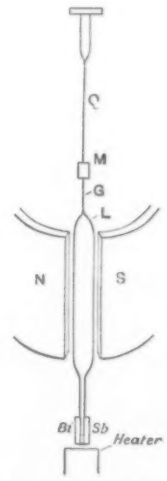


FIG. 2.—DIAGRAM OF THE GALVANOMETER.

to give the same scale deflection at the same distance was 108 millivolts, so that assuming 10 millimeters as the smallest measurable, and 0.1 millimeter as the smallest detectable deflection, the smallest measurable current is 23 micro-amperes, and the smallest detectable current 2.3 micro-amperes.

As a further illustration of the extreme sensibility of the thermo-galvanometer, Duddell states that if a Bell telephone receiver is connected to the instrument, a comparatively small noise of the right pitch is sufficient to generate enough current to throw the spot of light off the galvanometer scale. Another experiment showed that if the thermo-galvanometer was connected to the line wires of an ordinary telephone transmitter arranged in the usual way, whistling at a distance of from 15 to 20 feet away from the mouthpiece will cause deflections of several hundred scale divisions.

In measuring the currents in the antenna or receiving aerial of a wireless telegraph receptor, the instrument is connected in series with the open or closed circuit, when the current strength may be read directly from the scale in micro-amperes.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE ASSIMILATION OF FREE NITROGEN BY BACTERIA.

THE researches of bacteriologists have established the existence of three methods of fixing atmospheric nitrogen—by certain bacteria of the soil, by the symbiosis of algæ and bacteria, and by the bacteria of the tubercles of the roots of Leguminosæ.

The fixation of nitrogen in the soil, though long suspected, was first demonstrated in 1885, by Berthelot. This fixation, in the absence of leguminous plants, is accomplished chiefly by the organisms *Clostridium Pasteurianum* and *Azotobacterium*, which exist in the soil in great numbers. The carbonaceous food of these organisms consists of glucose, levulose, mannite, and other sugars. The oxidation of these carbohydrates furnishes the energy required for the assimilation and combination of atmospheric nitrogen. The presence of lime and phosphoric acid is necessary to the development of these bacteria and the aeration of the soil by frequent stirring favorably influences their multiplication and activity. By continual working, the nitrogenous constituents of the soil can be increased to such an extent that no increase in crops is produced by the addition of nitrogenous fertilizers. The *Azotobacterium*, furthermore, is five or six times more abundant in fallow than in cultivated land.

When the nitrogen-fixing power of these bacteria became known attempts were made to utilize it by inoculating the soil with the bacteria but no result of practical value has yet been obtained by this method. Such a result, indeed, appears impossible, for the fixation of nitrogen depends on the quantity of assimilable carbohydrates in the soil and the application of these carbohydrates would be a ruinously expensive method of obtaining nitrogen.

Inoculation with the bacteria of the tubercles of *Leguminosæ*, on the other hand, has given very encouraging results. The fact that leguminous plants increase the nitrogen content of the soil has long been known. The classical experiments of Hellriegel and Wilfarth proved that these plants assimilate atmospheric nitrogen by means of root tubercles containing bacteria of the species *Bacillus radicicola*. This organism can be propagated very easily by extracting sap from the tubercles with a sterilized pipette and transferring it to a sterilized culture liquid. In young tubercles the bacterium appears in the form of short rods, in older tubercles it assumes branched forms, which are called bacteroids. These root bacteria, disseminated through the soil, are attracted by the carbohydrates of the root hairs, and as the bacteria multiply, the cells of the root hairs undergo segmentation and produce the bacteroidal tissue. As the tubercle enlarges, the quantity of nitrogen contained in it and the root rapidly increases. The production of tubercles is favored by the presence of humus, unless this is in excess, as in peat land. Superphosphates promote the growth of tubercles in peas, vetches, and lupine, but have the opposite effect in the bean, in which plant the production of tubercles is increased by nitrogenous fertilizers.

The virulence of the bacteria is very variable. In young pea vines it can be increased, by successive inoculations, to an intensity which is injurious to the plant. It has also been discovered that after tubercles have been formed the plant acquires a certain immunity, so that bacteria of greater virulence than those which caused the existent tubercles are required to produce new tubercles. This discovery is of great practical importance, for it shows that inoculation is useless unless it is performed with bacteria more virulent than those which are already present in the soil.—La Science au XXme Siècle.

Municipal ownership of coal mines has been discussed for some months in the city council of Vienna, Austria, and it is reported that the city is now trying to secure control of mines in Moravia. The reasons given for the purchase are the high price of coal and the difficulty of securing a steady supply for the municipal gas and electrical plants.

AN EXPERIMENTAL MODEL BASIN.—I.*

A BRIEF DESCRIPTION OF ITS FUNCTIONS AND OPERATION.

BY NAVAL CONSTRUCTOR R. H. M. ROBINSON, U. S. NAVY.

THE original and fundamental idea in the establishment of experimental basins, or, as they are otherwise called, "model tanks," was to assist in the determination of the resistance of ship-shaped forms at various speeds of propulsion, and thence the deduction of the power required to drive a given form at a given speed, and also the most desirable form for any given speed.

Their functions have been extended to include experiments with propellers, tending toward the solution of the problem of the best form, dimensions, and locations of propellers, and to include other experiments of kindred nature in connection with problems of ship construction and propulsion.

Originally, the underwater forms of vessels were determined by experience with full-sized ships, or by considering, by looks and touch, the shape of a small wooden model.

Some experiments on the resistance of various surfaces were made in the eighteenth century by several naval architects and others interested in the subject; notable among these was Col. Beaufoy, the results of whose experiments were published in 1834.

In 1874, in a paper presented to the British Institution of Naval Architects, Mr. William Froude propounded what is now known as "Froude's Law," or the "Law of Comparison," which is a special application of the law of similitude, first propounded by Newton.

The whole usefulness of model-basin experiments is due to the truth of this law, which permits accurate and exhaustive experiments at reasonable cost, and the accurate determination of characteristics of a given model prior to building, which in turn permits ready determination of the horse-power necessary to give any required speed in the full-sized ship.

The law, which was deduced by Mr. Froude, with the aid of the British Admiralty, from consideration of results of experiments with the British ship "Greyhound" and with models towed in the basin at Torquay, may be expressed in the following words:

Eliminating the resistance due to skin friction, if a ship be D times the dimensions of a model of similar form, and if at the speeds V_1, V_2, V_3, the measured resistances of the model are R_1, R_2, R_3, then for speeds $\sqrt{DV_1}$, $\sqrt{DV_2}$, $\sqrt{DV_3}$, of the ship, the resistance will be D^3R_1, D^3R_2, D^3R_3.

The speeds V_1, V_2, V_3 for the model and $\sqrt{DV_1}$, $\sqrt{DV_2}$, $\sqrt{DV_3}$ for the ship are termed corresponding speeds.

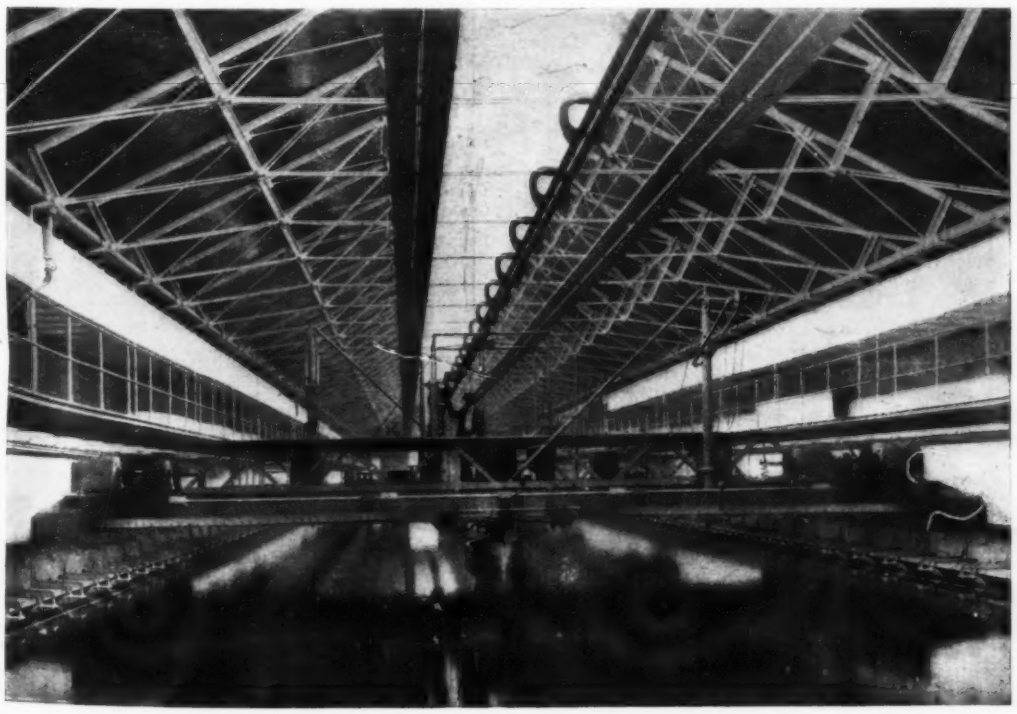


FIG. 1.

It was early found that the skin friction did not follow this law.

The three elements of ship's resistance have been determined to be, (1) skin friction, (2) eddy resistance, (3) wave-making resistance.

The total resistance, minus the skin friction, is termed the residuary resistance.

The skin friction of a ship has been found by many experiments to be practically the same as that of a plane surface of the same nature, area, and length in the direction of motion as the curved wetted surface of the ship.

The skin resistance of a ship may then be expressed as a formula:

$$Rs = fSV^n,$$

where Rs = skin resistance,
S = wetted surface in square feet,
V = the speed in knots,
f, n = semi-constants changing somewhat with the nature and dimensions of the surface and determined by experiment only.

Tables of these constants, as separately determined by Mr. R. E. Froude and Dr. Tideman, are given in Taylor's "Resistance and Propulsion of Ships."

The original experimental basin, as stated, was developed by Mr. Froude and was located at Torquay,

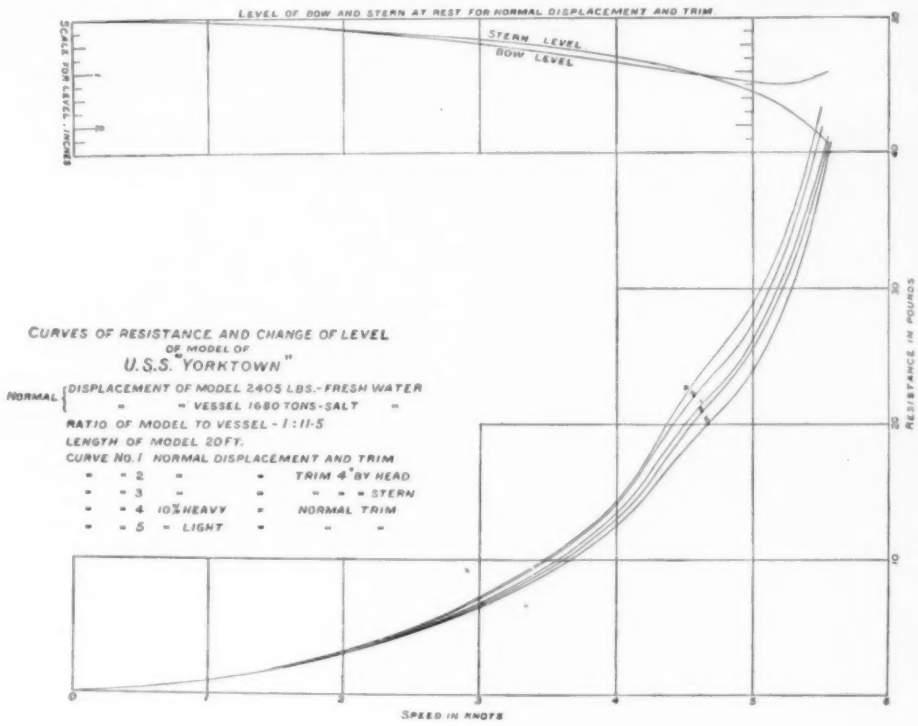

LEVEL OF BOW AND STERN AT REST FOR NORMAL DISPLACEMENT AND TRIM
SCALE FOR LEVEL - INCHES
STERN LEVEL
BOW LEVEL
CURVES OF RESISTANCE AND CHANGE OF LEVEL
OF MODEL OF
U.S.S. "YORKTOWN"
NORMAL { DISPLACEMENT OF MODEL 2405 LBS.- FRESH WATER
" = VESSEL 1680 TONS-SALT "
RATIO OF MODEL TO VESSEL - 1:11·5
LENGTH OF MODEL 20FT.
CURVE No.1 NORMAL DISPLACEMENT AND TRIM
" - 2 " " TRIM 4" BY HEAD
" - 3 " " " " STERN
" - 4 10% HEAVY " NORMAL TRIM
" - 5 - LIGHT " "
RESISTANCE IN POUNDS
SPEED IN KNOTS

FIG. 2.

being established in the seventies. (The British experimental station has since been removed to Haslar.) Since that time a number of experimental stations have been established, both by private firms and by governments. A partial list of such stations follows:

EXPERIMENTAL MODEL STATIONS.

Date.	Location.	Length	Breadth	Draft
1884	Leven Shipyard, Dumbarton..	300	20	8.8
1886	Haslar	400	20	9.2
1889	Spezia	479	19.7	9.8
1900	North German Lloyd S. S. Co., Bremerhaven	538	19.7	10.0
1903	Charlottenburg	528	34.5	11.5
1904	John Brown & Co., Clydebank.	490	32.0	10.0
1899	U. S. Government, Washington, D. C.....	470	42.8	14.8
1905	University of Michigan, Ann Arbor	300	22	10
1907	French Government	(Just completed.)		

All these vary in matters of constructional detail, but all aim at the same results, and the variations are due in most part to differences of local conditions or considerations of expense.

Probably one of the most complete is the U. S. Government basin located at the U. S. Navy Yard, Washington, D. C., and operated under the Bureau of Construction and Repair of the navy. The design and installation of this basin was under the direction of that able officer, Naval Constructor D. W. Taylor, U.S.N., who has also been in charge of the experimental work since the opening of the basin in 1900.

The basin holds about a million gallons of water. It is filled from the city supply for Washington.

Before reaching the basin the water is treated with a small quantity of alum, which removes any mud present, and is then clarified by passing through a sand filter.

A small stream is kept constantly running through the filter to freshen the water after filling, and to make up for leakage and waste.

The basin can be pumped dry in about four hours by an electrically-driven centrifugal pump. Two other electrically-driven pumps are fitted, a four-inch centrifugal pump connected with troughs on each side of the basin just at the surface, by which the water can be "scummed," and a small plunger pump used for drainage and piped to take the water from inside or outside the basin as desired.

The building is heated by hot air. The temperature

* For the greater part of the description of the United States model basin and the apparatus, contained herein, I am indebted to the Society of Naval Architects and Marine Engineers and to Naval Constructor D. W. Taylor, U. S. N., with whose permission they have been used.—R. H. M. R. Copyright by the United States Naval Institute, Annapolis, Md., and reprinted by permission from the Proceedings of the United States Naval Institute.

is generally kept slightly higher than is usual for an ordinary living or working room. Otherwise the operators of the traveling carriage are liable to discomfort from their constant motion to and fro through the damp air.

Steel troughs about 12 inches square in sections are located on each side and just below the usual working level of the water. They act as absorbers of wave disturbances and cause them to die away rapidly. In addition there is at one end of the basin a "wave-breaker," consisting of a large number of square strips of wood set vertically at varying distances apart. These, with the side troughs, reduce any wave motion into minute ripples by the time eddies and currents due to the passage of the model have been dissipated. Without wave-breaking appliances, running trials at high speeds would be a long operation as long waits between runs would be necessary to allow the waves to subside.

The apparatus for measuring the resistance of models is carried on the traveling carriage which spans the basin as shown in Fig. 1. This carriage weighs about 70,000 pounds, and hence has sufficient inertia to resist sudden variations of speed.

The carriage is driven by four motors, one on each corner. The speed is controlled on the Ward-Leonard system. Current from an "exciter" generator at 110 volts keeps constant excitation in the field coils of the motors and current from the same exciter passes through the controlling rheostats on the carriage and also around the field coils of the main generator.

The main generator runs at constant speed controlled by a governor which limits variation of speed within 1½ per cent from no load to full load. The generator armature is in series with the motor armature, so that all the current developed at the generator passes through the motors, the voltage at the generator varying according to the amount of excitation of the generator fields which is controlled from the carriage.

The four motors are so arranged that they may be connected all in series, or two and two in series, the pairs being parallel.

The maximum generator voltage is 250, and as there are two generators which can be arranged in series, the maximum available voltage is 500. The motors are geared together, two and two across the carriage, and also geared down to the main driving wheels. In addition, the forward pair of motors has back gearing for low speeds. For many experiments one generator only is required, the motors being arranged all four in series for speeds ranging from ½ knot to about 6½ knots, and two and two in series parallel for speeds from 6½ knots to about 12½ knots.

The maximum speed at which the carriage can run is about 20 knots, developed in a run of about 200 feet.

With such a heavy mass moving at this speed in a confined space, very careful provision is required for stopping.

With the Ward-Leonard system a powerful electrical braking effect is obtained from the driving motors, through the back current generated when the exciter current around the generator fields is shut off or reversed. This enables the carriage to be stopped more rapidly than it is started. This method of stopping is not relied upon solely, since it fails if the circuit is broken either accidentally or by the automatic circuit breakers in case of an overload. This method also necessitates proper manipulation on the part of the person operating the carriage. At least one method of braking to stop the carriage in the minimum possible distance was desirable, independent of the electric current, and not requiring manipulation by the operator. Wheel brakes could not be used, as they would cause objectionable wear on the wheels of the springless carriage, and would stop it no more rapidly than the electric brake supplied by the Ward-Leonard system (it may be noted that from time to time the wheels require truing up to insure accurate measurements). Friction brakes closed by hydraulic pressure were therefore fitted. These are fitted at the north end of the basin in the form of a pair of iron strips on each side, securely anchored at one end to the main walls of the building, and pressed together by hydraulic cylinders. They are 15/16 inch apart when the pressure is on and 1 1/16 inches apart when it is off, being pulled apart by springs when the pressure is released. A strip of iron about 1 inch thick and 12 feet long is securely bolted to each forward corner of the carriage, and is adjusted to enter without shock the space between the stationary strips, and by friction against them bring the carriage to rest. Hydraulic pressure is obtained from a small electric pressure pump, and an accumulator is fitted, through which the pressure can be varied from 100 pounds to 600 pounds per square inch. Two gages at the south end of the basin indicate the pressure in the hydraulic cylinders, so that the operators may know before starting a run that the friction brake has pressure on. The strips are kept lubricated in order to avoid seizing or violent shock.

In addition to these, there is an emergency brake, which takes hold of the carriage if it should get through the friction brake without being arrested. This consists of a taper piston rod passing through a round hole in the cylinder head, which it gradually closes as it moves; the principle is the same as the hydraulic recoil brakes for heavy guns. The hydraulic cylinder is below the water level when the basin is full, and when this is the case the emergency brake is always ready. The parts of this brake are bolted in place by fastenings which will be broken in case the brake comes into action, but up to the present time this has never happened.

Paraffine, which is largely used for models in experimental basins abroad, has many advantages, but cannot be used in Washington, as it will not stand the summer temperature without too much softening.

As compared with paraffine as a material for the construction of models, white pine has the following advantages:

1. Wood retains its shape better during changes in weather.
2. Wood is many times stronger.

Its disadvantages are:

1. Wood is harder and more expensive to fashion.
2. Wooden models are harder to keep tight.
3. Wooden models are harder to give a uniform surface.

The first and second objections have been overcome by the adoption of special machinery designed by Naval Constructor Taylor, and the third by using a special varnish to finish the models, which gives a surface practically uniform.

Owing to the greater strength of wood it is feasible to make models 20 feet long, and the sectional area of the basin is such that these models may be run with no greater interference from the size of the basin than 12-foot models in the smaller foreign basins.

The advantages of this size, as compared with the 12-foot size, in determining resistance, are great. It is found that for the 20-foot models of many U. S. naval vessels the resistance at the speeds corresponding to the actual maximum speeds of the vessels is below 40 pounds. With 12-foot models the resistances would have been below 9 pounds. A 20-foot model is 1/1,728 the displacement of a 240-foot vessel, and 1/13,824 that of a 480-foot ship.

For a 12-foot model these figures are 1/8,000 and 1/64,000, respectively.

With the large model, resistance is measured more easily to a given percentage of accuracy, and the gap between models and ships to be bridged by the law of comparison is not so great.

It is the usual practice at the U. S. model basin in the case of models of men-of-war to determine five resistance curves, each extending somewhat beyond the speed corresponding to the maximum speed of the vessel. These curves are as follows:

No. 1. With the model at a displacement corresponding to the designed normal displacement of the ship and at the designed trim of the ship.

No. 2. With the model as in No. 1, except the trim is changed four inches by the head.

No. 3. With the model as in No. 1, except the trim is changed four inches by the stern.

No. 4. With the model as in No. 1, except that it is 10 per cent lighter.

No. 5. With the model as in No. 1, except that it is 10 per cent heavier.

Fig. 2 shows these five curves for a model representing the "Yorktown." The displacement of this vessel corresponding is 1,680 tons and the designed trim 2 feet 1½ inches by the stern. The maximum speed of the "Yorktown," when tried at 1,680 tons, was 16.7 knots. The corresponding speed of the model is 4.93 knots. The curves of Fig. 2 are carried higher in proportion to the designed speed of the vessel than is necessary.

The speeds of 20-foot models corresponding to the maximum speeds of some of our battleships are given below:

Battleship	Length	Maximum	Corresponding Speed of 20-foot Model
"Oregon" class	348	16.8 trial	4.03
"Iowa" class	360	17.1 "	4.03
"Kentucky" and "Alabama" classes	368	17.1 "	3.99
"Maine" class	388	18	4.09
"Georgia" class	435	19	4.07

Fig. 1 shows the carriage in operation, towing a model of the battleships of the "Georgia" class.

(To be continued.)

Anti-Dry-Rot Varnish for Wood.—Ingredients: 200 parts of borax, 100 parts boracic acid, 250 parts of vinegar spirit and 2,500 parts of water. The whole is heated from 140 deg. to 158 deg. F. and 200 parts of spirit added before use. The wood is coated two to three times and after drying the following varnish is applied: 200 parts of borax, 400 parts of shellac and 2,000 parts of water, heated in a water bath until solution is effected, then mixed with 1,000 parts of hot water, allowed to cool, and finally strained if necessary. (Must be applied during dry weather.)

REED LATHS IN SWEDEN.

THE following information concerning the preparation and use of reed laths in Sweden, where wood laths, on account of their cost, are now little used, is furnished by Consul W. Henry Robertson, of Gothenburg:

Although Sweden is a country of unusually extensive forests, in proportion to its size, and is, therefore, better able than many other countries to stand a strain upon its wood products, it is found here that certain reeds form a much cheaper material than wood laths in the plastering of ceilings and wooden walls of buildings.

These reeds are of the common kind, known to botanists as *Phragmites communis*, and as they grow wild in large quantities almost everywhere in central and southern Sweden, on the borders of lakes, ponds, rivers, smaller water courses, and in marshy places, it is thought that builders and farmers in the United States might do well to look into the entire proposition with a view of seeing whether these or similar reeds, that undoubtedly grow wild also in the United States, could not be utilized for the same purpose and their growth artificially cultivated and extended. This would give rise not only to a cheaper building material, but to an industry of growing and harvesting the reeds, and manufacturing them into a sort of matting, where this is found preferable to using them in their raw state in building operations.

As to the methods used here in applying both the raw and the manufactured reeds to the walls and ceilings, as well as the machinery used in making the latter, it is thought that it would be easy materially to improve upon both, and it is the certainty of the ability on the part of Americans to do this with facility that makes the whole proposition capable of development and of a thoroughly useful application to our building operations. It is also not at all impossible that experimentation and development along the one line might show the reeds suitable for other purposes.

The reeds are used in Sweden in both the raw state and in the form of a woven sort of matting, according to the customs and preferences of the builders.

The method, however, that would be most likely to appeal to American builders is the one where the reeds are woven into a matting which is much more readily nailed to the walls and ceilings than where each reed is nailed on and wired by hand.

The following is a careful translation of a price list of the largest Swedish firm manufacturing the reed mats:

Mats to be used single, in widths of 2, 1.90, 1.80, 1.70, 1.65, and 1.5 meters (1 meter = 39.37 inches); mats, to be used double, in widths of 1.7, 1.65, and 1.5 meters, delivered in rolls of 20 square meters (1 square meter = 10.76 square feet), at a gross price of 65 cents per roll.

In single reeding the mats are nailed to walls or ceilings in the same way, viz: Fasten all wires of one end of the mat, unroll the mat over the wall or ceiling; stretch the middle wire tight, be careful and see that the mat hangs or lies straight, and then stretch the other wires in the same degree as the first one. Then fasten every wire by nails placed about 6 or 8 inches from each other.

For ceilings the connecting edges of the mats should be dovetailed so as to make a joint about 5 inches wide, and loose wires are stretched along the joint and fastened in the usual way with 1-inch plastering nails.

For double reeding of ceilings or outside walls mats with larger spaces between the reeds are used; the inside mat is put on in the ordinary way, although a somewhat larger space between the nails may be allowed. Then the second mat is put on in such a way that its reeds come at right angles to the reeds of the first mat. The fastening is done with 1¼-inch plastering nails.

As will be seen from the above the mats are of two different kinds, one more closely woven of heavier reeds, to be used single, and the other more openly woven of thinner reeds, to be used double. The warp in each case is annealed iron wire. The mats are delivered in rolls.

The plant from which the reed grows is known by several names in Sweden, but is most commonly called "vass," or "vassrör." It seems to thrive best in shallow water on the edges of lakes, but it is also sometimes found as a weed among growing grain on low ground. It is the largest of the wild grasses in Sweden, and is considered good fodder for cattle, for which purpose it is often cut green. The tops are also sometimes cut off before they go to seed, and are then used by farmers as stuffing for beds and mattresses.

The full-grown reeds are about 7 or 8 feet high above water, and, when they are to be used as a plaster-fastening material, they are cut in winter, after the leaves have dropped off and the lakes have been frozen over. They are never harvested in boats. The frozen surface of the lake makes the reeds much more accessible than if one had to reach them through wa-

ter or swampy land; but they should be cut as early in winter as possible, before the snow has broken them. The reeds are not cultivated in Sweden, but are regarded as so common that it is impossible to procure the young plants or the seed except by giving a special order for some one to go into the country for them at the proper seasons of the year, the spring for the plants and the fall for the seed.

There are no special purchasing agents or concerns in Sweden for the harvesting of the reeds. On the largest number of farms where such reeds grow the farmers themselves cut the reeds and sell them to the so-called revetting factories. The prices vary considerably in different years. On the average a bundle with a cross-section of 10 inches at the lower tie or brace, about 1 foot from the root end, costs, delivered on railroad car, 8 to 9 cents. The reeds are also often bought in stooks of 20 bundles, each bundle being about 2 feet in circumference, and costs about $1.07 per stook, or shock.

The mats are of different widths, from 1 to 2 meters, according to the length of the reeds. They contain about 20 square meters and have a selling price at the factory of about 1.90 kroner (50.9 cents) per mat, or about 10 öre per square meter (2.7 cents per 10.76 square feet). It is impossible to state with accuracy the number of mats made and sold in Sweden in a year.

A manufacturer writes as follows:

Reed laths are probably just as durable as wood laths. The writer has seen houses torn down which were at least seventy-five years old and found the reeds nailed to the walls just as sound as when they were put there. All depends, however, upon the manner in which the reeds are harvested and kept, because they are easily damaged if the bundles are kept wet or covered with ice. Wood revetting mats are scarcely manufactured any more in Sweden, because they are too expensive. Besides that, the reed mats are considered better and more practical, because when such are used the surface of the plastering does not crack, which was often the case when unseasoned wood laths were used. So-called loose reeding is used a great deal; that is, the loose reeds are nailed to the walls and ceilings by hand. If skilled workmen are available, such reeding can be just as good and practical as the mats. Whether one or the other of the two systems is used depends a great deal upon the custom of the respective building contractors. The old ones, among whom there are a number of conservative persons who hold on to old methods, prefer the so-called loose reeding. No practical preference can be given to either of the methods, except that when mats are used the reeding can be made more quickly and specially experienced workmen are not needed. The use of reed mats is also increasing, as compared with the use of loose reeds.

From the foregoing it will be noted that wood revetting mats are scarcely manufactured any more in Sweden, the reed mats being considered better and more practical for several reasons. The question not unnaturally occurs, however, as to whether it might not be a good idea for American lath manufacturers to try the use of wood revetting mats made after the Swedish model in case it should be found impracticable to grow or import the reeds. It would seem to furnish a cheaper and quicker method of attaching the laths to the walls and ceilings with much less labor. It appears that the insulating properties of wood and of the reed laths are considered equal.

The manufacturer who supplied the prices and the mode of putting up the reed mats supplies similar information concerning the price and putting up of wood laths, as follows:

Dimensions, 1 by 20 meters, at a list price of $1.34 per roll. The fastening of wood lath mats is done in the same manner as described for reed mats. Lath nails 1¼ inches in length are most suitable, and the nails should be driven in through the small opening found between the twisted wires close to the lath. In order to facilitate the making of proper seams or joints between two mats, the end of every other lath protrudes beyond the next one.

The supply of reeds in Sweden is very large and much in excess of the home demand, so that great quantities, which are never harvested, could be available for export. The fact that the mats have not been exported to the United States is very likely due to the transportation costs for such cheap and bulky goods. All depends ultimately upon what price could be obtained for the mats in the United States and whether the reeds themselves could be cultivated and harvested there at less expense than it would cost to import them. If the reed mats could bear the freight charges to the United States, there should not be any insuperable obstacle to the import of such from here. Still, it might be found more practicable to import the loose reeds and make them into mats in the United States. Or, better still, in case the reeds already grow, or can be made to grow, in the United States, machines for the manufacturing of the mats could readily be purchased here and improved upon. The matter seems well worth careful investigation, and this consulate stands ready at any time to give any further specific information that may be desired and that is procurable. The question is one that must be looked at both from the agricultural or producing standpoint and the commercial standpoint.

THE SPEED OF AN AEROPLANE.

HOW IT MAY BE DETERMINED.

BY DR. A. F. ZAHM OF THE GEORGE WASHINGTON UNIVERSITY.

THE plan of the United States Signal Corps for determining the speed of aeroplanes in the contemplated tests at Fort Myer this summer, raises the question of the accuracy of their method. They purpose to observe the duration of flight and the distance traversed *over the ground*, and from these compute the velocity *through the air*. They will say the speed through the air equals the distance traveled over the ground divided by the time of transit. The question is to find the error involved in this method, if there be a perceptible breeze.

It is manifest that, if a strong wind prevail, the ground method is faulty and objectionable. In such case it would be much fairer to the owner of the machine to determine its speed by means of an anemometer carried by the aeroplane itself. But the Signal Corps makes the natural reply that the flights need not be made in a strong wind, and that in a mild breeze their method is not less accurate than the anemometer method. As this claim is well grounded, let us examine it analytically.

Let us take the simplest case first. Assume that a steady wind blows, and that the flight is made to and fro, an even number of times, over a long rectilinear course in the direction of the wind. Let us adopt the following symbols

v = velocity of aeroplane through the air.

v' = velocity of aeroplane over ground.

nv = velocity of air over ground.

n being a numerical constant less than unity, and all three velocities being assumed constant, to simplify the discussion. Then if t be the duration of flight, and $2l$ the total distance flown, we have evidently

$$t = \frac{2l}{v'} = \frac{l}{v + nv} + \frac{l}{v - nv} \qquad (1)$$

Simplifying this equation there follows:

$$v' = (1 - n^2)\, v \qquad (2)$$

which is the formula for finding the relation between the true speed over ground and the true speed through the air in the simple case cited.

It is evident from a glance at the above formula that, in favorable weather, no great error will be involved in the signal corps method applied to a long straight course, as described. For example, if the wind blow 5 miles an hour and the true aeroplane speed v be 50 miles an hour, n is 1/10, and $v' = 0.99\, v$, or the government method gives a speed one per cent smaller than the true speed. If the wind speed be 10 miles an hour and the flight be 50 miles an hour, n is 1/5, and the error is four per cent. It will doubtless be practicable to choose weather for which n will be less than 1/5, especially if the flights be made near the ground.

Under the simple conditions cited, the ground method will probably be as reliable as the anemometer method. For the anemometer may not measure accurately to four per cent or less. Its reading may be disturbed by proximity to the machine. It may include in its record the sinuosities of the motion of the wind and the aeroplane, which the government may not like to count as a part of the velocity it has contracted to pay for.

In order to make the government test still more accurate, for the case just considered, I would recommend that n be carefully determined by means of an anemometer stationed on the course, and then v be computed by use of formula 2. This computation could not introduce a large error, if the anemometer were fairly accurate, and would doubtless eliminate a part of the error, made in writing $v = v' = \frac{2l}{t}$, as in the direct ground method.

Now assume, more generally, that the aeroplane flies on a long straight course to and fro, and that the wind blows with constant speed nv, at a fixed angle α, to the course. In this case the speed v_r, say, of the aeroplane along the course, at any instant, will be the resultant of the two speeds v and nv, or

$$v_r = \sqrt{1 - n^2 - 2n \cos \alpha}\; v$$

Writing the equation for the time of flight, there follows:

$$t = \frac{2l}{v} = \frac{l}{\sqrt{1 - n^2 - 2n \cos \alpha}\, v} + \frac{l}{\sqrt{1 - n^2 + 2n \cos \alpha}\, v} \quad \ldots\ldots (3)$$

One of the radicals being for the forward motion, the other for the return. If α be zero, this formula gives $v = (1 - n^2)\, v$, the same as equation 2. If α be 90 deg., that is, if the wind blow at right angles to the line of flight, the formula becomes:

$$v' \sqrt{1 - n^2}\, v \quad \ldots\ldots \quad \ldots\ldots (4)$$

Comparing equations 2 and 4, it is seen that v is more accurately given by the latter; that is to say, the line of rectilinear flight should be chosen at right angles to the wind, rather than in its direction. For intermediate angles v will have intermediate values, which need not engage us here.

In the most general case the wind will blow with varying speed along a curved path, and the aeroplane will move in a curvilinear course. The time of passing over any length s of the course may then be written:

$$t = \frac{s}{v'} = \int_0^{s} \frac{ds}{v_t} \quad \ldots\ldots \quad \ldots\ldots \quad \ldots\ldots (5)$$

In which v_t is the instantaneous tangential component of velocity along ds. If the equation to s be given, and the wind velocity be given as a function of the path or time, this equation will determine v in terms of v' and the specification of wind and course.

The general equation 5 might be applied to some particular courses, say circular or oval, but it is apparent from what precedes, that in all cases the value of v' will lie between $(1 - n^2)\, v$ and $\sqrt{1 - n^2}\, v$, provided the average opposing component velocity of the wind over one-half of the course equal the average conspiring component of velocity over the other half. This would be practically the case for a long flight round a short course, as planned for the test at Fort Myer this summer. For a closed nearly circular course, therefore, I would recommend that the aeroplane speed v be computed by means of formulæ 2 and 4, and the mean taken as the true speed, n being determined by means of one or two anemometers stationed on the field.

We may conclude, therefore, that the ground method of the United States Signal Corps is accurate enough for practical use, especially if v be computed from v' and n, as proposed. Indeed it is questionable whether in very calm weather such method may not be used to advantage even to calibrate anemometers, if they be carried over a smooth course.

The application of electricity is fast revolutionizing many industries, and an interesting application in the chemical industry is described in the Journal of the Franklin Institute by Mr. E. R. Taylor, who gives an account of the process and apparatus for the production in the electric furnace of carbon bisulphide, the manufacture of which in retorts is one of the most disagreeable of manufactures. The furnace used is 10 feet in diameter and 20 feet high, and will produce 5,000 pounds per twenty-four hours with economy and satisfaction. Two electrodes only are provided. The market for carbon bisulphide is a limited one, and no larger furnace than those now in use would be justified under present conditions. But were the market for carbon bisulphide as large and as regular as that for pig iron, the size of the furnace need only be limited by market requirements and the amount of electricity available.

THE MAKING OF MOVING PICTURES.—II.

HOW THEIR FANTASTIC EFFECTS ARE OBTAINED.

BY GUSTAVE BABIN.

Concluded from Supplement No. 1697, page 26.

IN a former article I pointed out the remarkable effects produced by transplanting a theatrical scene into a natural environment. The makers of films have taken advantage of this, and often perform a drama in an appropriate natural setting, after it has been well rehearsed on the boards. For example, "Blue Beard" is performed in the empty halls and on the deserted ramparts of Pierrefonds; and quite recently a troupe of forty persons was sent by the Gaumont establishment to Carcassonne, where it performed a historic pantomime, the "Departure for the Crusade." Thus, also, the pantomime of the "Enchanted Guitar," of which we reproduce an episode, was enacted. I have spoken of sudden appearances and substitutions of one person for another, or for an object, and said that these were produced by stopping the apparatus; but there is another class of visions which are perhaps more striking and more puzzling. This is the class of gradual apparitions, a sort of materialization calculated to impress the most skeptical. It produces phantoms which appear to be made of pure light and color, subtle vapors which are seen to float over the ground like evening mists, and then take form and condense into human figures, elves, jinns, or sylphs. Of all such scenes which I have seen projected, the most perfect, I think, is the "Dance of the Jinns." From the many-colored silks of a Persian rug appears a white transparent figure, at first scarcely visible and with uncertain lineaments, through which may be perceived the arabesques of the rug, but which gradually becomes transformed into a living person.

The process here employed, which is technically called the *fondu*, is a very ingenious improvement upon the method of pauses. The phenomena are produced by skillful manipulation of the diaphragm of the camera. Of the three films here reproduced, two are purely explanatory and serve to show the two distinct stages of the operation, while the third shows the final result. This is the film which is projected, and by examining it attentively one can see the gradual formation of the image of the little dancing girl at the right hand. This result is obtained in the following manner:

At the moment at which the operation is to begin, a whistle is heard which warns the actors, who have already taken their places, to remain quite motionless for a few seconds. Then the operator, continuing to turn the crank of the apparatus with uniform motion, gradually closes the diaphragm. It is easy to understand that upon the strip of film which has passed before the lens during this time, the length of which strip is indicated by a registering piece, the successive pictures would have an intensity gradually decreasing to entire extinction if the film were developed in this condition, as has been done here solely for the purpose of demonstration.

In order to have the figure of the first or left-hand dancer always sharp and conspicuous, it is then necessary to give to the later images the amount of exposure of which they have been deprived. It is in this second period also that the vision is to appear. While the second dancer who plays the apparition takes her place on the scene, the operator, by turning the handle backward, brings the strip of film exactly to the point which it occupied when the whistle blew, the finding

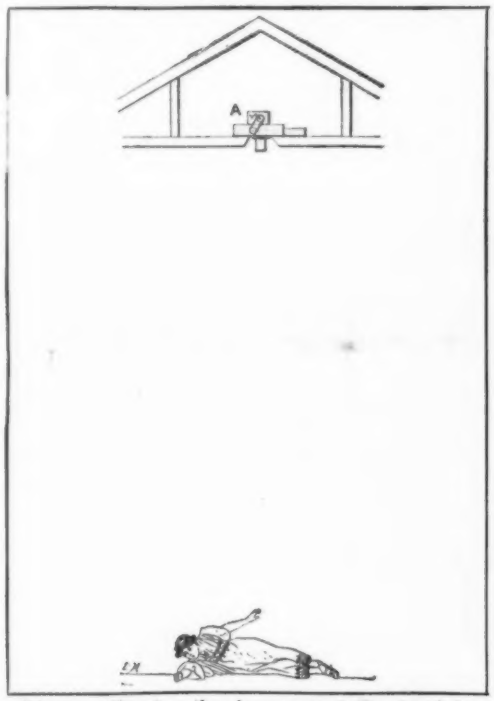


Diagram Showing the Arrangement Employed in Making the Series "The Siren." The Recording Cinematograph is Set up at A.

How "The Siren" Appears on the Moving Picture Film.

Pumpkins Thrown Out of a Window and Rolling Down Hill Are Caused, by Reversing the Movement of the Film, to Appear to Roll Up Hill and Fly Up to the Window.

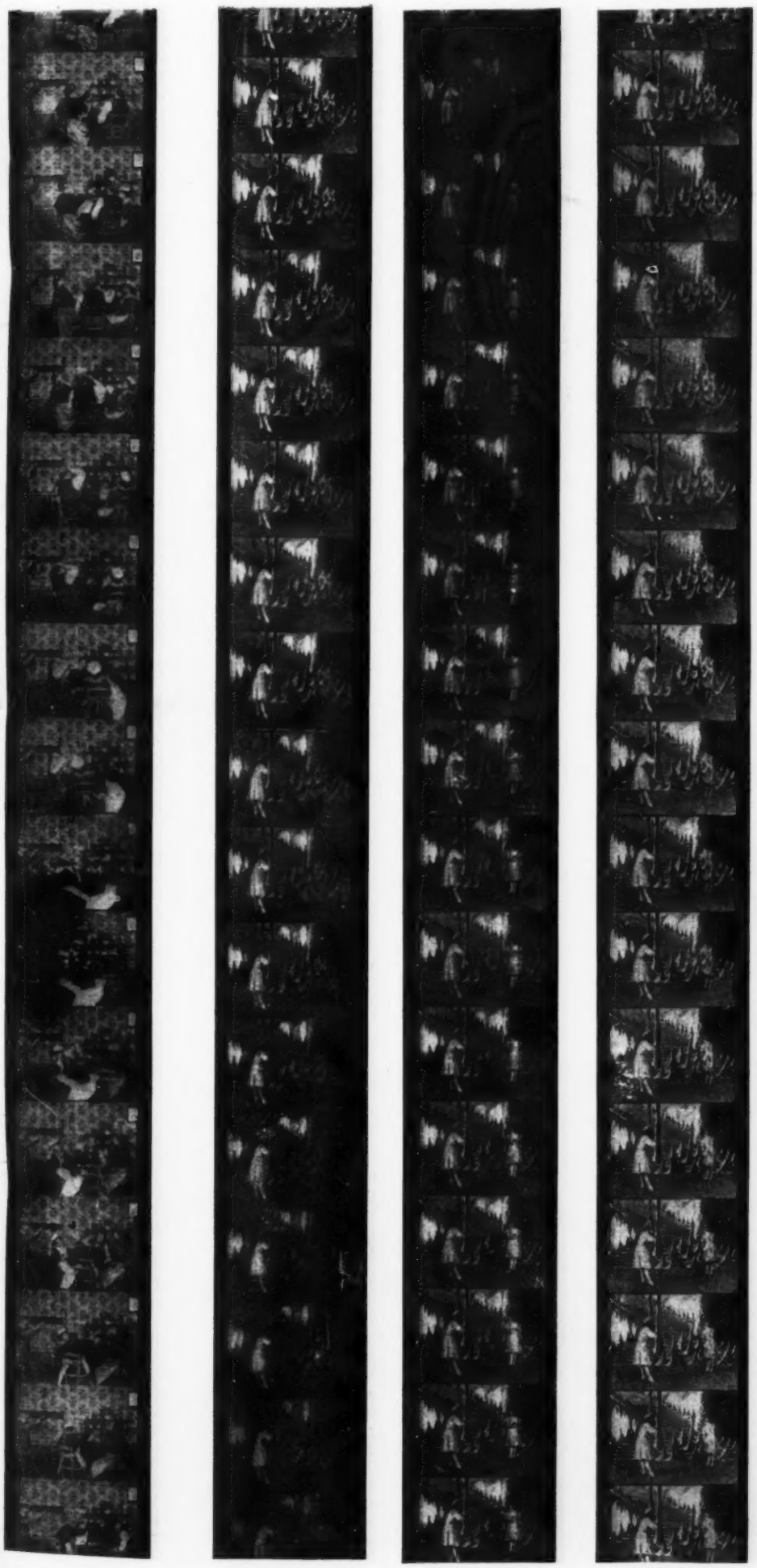
THE PUMPKIN RACE.

The Actress Performs Her Evolutions on a Scene Laid on the Floor of the Stage and is Photographed from Above on a Moving Film Which Already Bears a Faint Impression of an Aquarium. (Snapshot.)

THE SIREN.

of which point is facilitated by the registering device. This is the part of the film which has been longest exposed and is consequently least sensitive, and as the diaphragm is closed it will receive, at first, only an infinitesimal quantity of light. Then, as the crank of the cinematograph is turned, the diaphragm is gradually opened in the same time that was occupied in closing it. This second exposure would produce on a new film the effect shown in the second strip of pictures here printed for explanation, but in practice the two series of pictures are superposed upon a single film. The consequence is that the exposure of each of the pictures which were underexposed in the first operation is completed during the second operation in such a manner that all the pictures have the same intensity. At the same time the second dancer, who has now taken her place, to impersonate the apparition, is photographed first with a small diaphragm opening, giving a picture almost invisible on the film which has already been well exposed, then with gradually increasing aperture on less exposed portions, and finally with the full aperture upon a part of the film which has scarcely been exposed at all. Hence the second dancer appears as distinctly as her partner in the last, and only in the last of the twice-exposed pictures. After this she advances, performs her dance, and the action resumes its normal course.

If in place of an apparition a disappearance is desired, the subject is simply left in position during the first exposure while the diaphragm is being closed. This method is also excellent, and better than the method of pauses for the substitution of one person for another. For this purpose the first exposure is made



A Moving Picture Curiosity.

THE REVOLVING TABLE.

Film Exposed with Closing Diaphragm.

Film Exposed with Opening Diaphragm.

Result of Both Exposures on a Single Film.

AN APPARITION PRODUCED BY DOUBLE EXPOSURE OF THE FILM.

A SCENE OF "THE ENCHANTED GUITAR" PERFORMED UNDER THE RAMPARTS OF CARCASSONNE.

Between the Second and Third Pictures the Apparatus Was Stopped and the Change of Costume Effected.

THE FOUNTAIN OF YOUTH.

as before, the strip is turned backward to the beginning, the second person takes the place of the first, and the second exposure is made while the diaphragm is gradually reopening. In other words, the substitution is obtained by combining an apparition with a disappearance.

A process which produces such admirable effects should soon replace the older methods of producing apparitions, and in many theatrical spectacles the cinematograph has already replaced the translucent screens and trapdoors of the past. The method of substitution by pauses is still used in some cases, for example, in "The Fountain of Youth." The subject of this series is the classic fable of the fairy disguised as an old beggar woman whom the good-hearted young squire rejuvenates by appropriate means—a kiss in some versions. But this transformation, which often appears ridiculous when the rags are stripped off and disappear through a trapdoor, becomes very effective in moving pictures. The scene may be a park with trees waving in the breeze, and this natural environment greatly enhances the effect of the transformation.

The series of pictures called the "Revolving Table" is produced by manipulation of the films. The story is that of a lad who having been hypnotized, has retained so much magnetic power that he cannot brush against another person in the street without putting him to sleep, and whenever he enters a house he starts all the furniture and all the inmates dancing. So in the pictures we see the table spinning with dizzy speed and carrying the guests around with it. Here we have in the first place a mechanical device. The table and floor turn on a pivot, but still it would be impossible to turn them so swiftly without throwing down the persons or driving them away by centrifugal force. Really, the mechanism moves quite slowly. Then at short intervals along the film portions are cut out, and the parts left are pasted together. In our engraving the places where this is done are indicated by white marks. The result is that a movement which has taken perhaps a hundred pictures to record is reproduced in projection by twenty or twenty-five, consequently the reproduction is effected four or five times as quickly as the recording, and the motion is correspondingly accelerated.

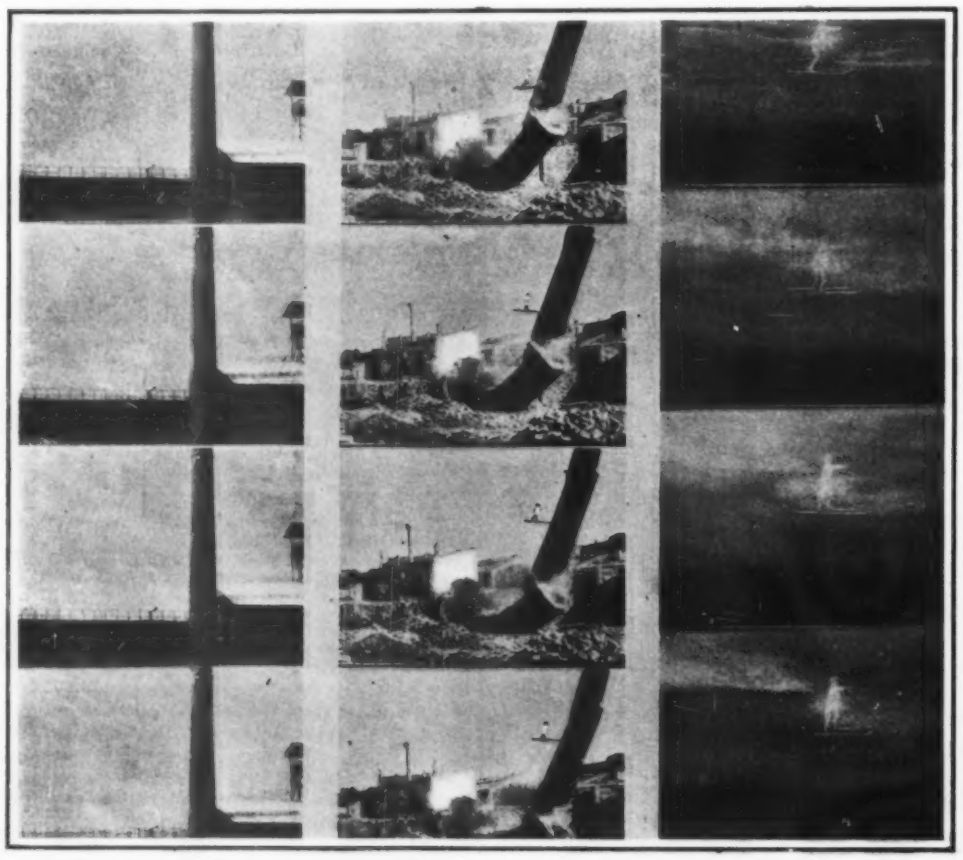
This process is much used, as for example in representing boys playing leap frog, children tumbling on the grass, etc. In another series a magician causes a crowd to dance with frantic speed. The same result can be obtained by making the exposure slowly and the projection rapidly. This was the first method used, but the method of cutting the bands gives a better effect.

In the "Pumpkin Race" the astounding effect depends upon the nature of the apparatus itself. In ordinary cases the film passes before the lens in the same direction at exposure and during projection. If the direction is reversed in either part of the process, all the actions represented will appear reversed. Thus, a man walking upstairs will appear to be walking downstairs backward, one jumping from a wall to the ground will appear to jump backward from the

MAGIC CARPENTER'S TOOLS WHICH WORK WITHOUT HUMAN AID.

(From an American moving picture film.)

ground to the wall, any falling object will appear to rise, and smoke rising from a chimney will appear to flow into it. In practice it suffices to invert the apparatus during the making of the record. In the "Pumpkin Race" we see four large pumpkins rolling up a steep street, rising in the air, and flying in rapid succession into a window of a house. In reality they were thrown out of the window and rolled down the street. By the same method we obtain the omnibus which moves backward, dragging its horses backward despite their frantic gallop. So also a plumber with several heavy pipes on his shoulder is seen to rise into the air like a balloon. The "Ski Runner" is produced by a special manipulation of the film. The series represents a skater who collides with a factory chimney, knocks it down, skates over the clouds, and finally vanishes into thin air. In the first part of the exposure the actor simply skates along a terrace toward a chimney of the Gaumont establishment. When he touches this it appears to fall, but the attentive observer will note that the chimney and the scene in general undergo a change. It so happened that a factory chimney in Belleville was to be destroyed. The operation was curious, and in itself gives an interesting series of pictures. The chimney was undermined, supported on wooden props, and these were then destroyed by fire. All this was photographed on the moving film. This film having been preserved as a curiosity, the happy inspiration came to make use of it in connection with the ski runner. The skater was next photographed on still another film, with a neutral gray background and very slight exposure. This was combined, in printing, with the film which showed the destruction of the chimney, giving the series which we reproduce, in which the skater appears to cause the catastrophe. His flight through the sky is obtained still more simply. The moving film was first exposed with a very small aperture to a cloudy sky, and the ski runner skating before his neutral background was then recorded upon the same film with full aperture.



A B C

Series A Shows the Skater Moving Along a Terrace Toward the Gaumont Chimney. Series B was Obtained by Combining, in Printing, Two Negative Films, One Taken During the Demolition of a Chimney, the Other Showing the Runner Against a Gray Background. Series C was Obtained by Photographing the Skater on a Film That Had Previously Been Exposed Before a Cloudy Sky.

THE SKI RUNNER.

The apparition of the siren in the depths of the sea surrounded by fishes and marine vegetation is one of the newest of series and is very effective. A woman clad in flowing drapery is shown gliding, swimming, diving, with the supple grace of a carp, in a mass of moving water, scintillating with rays of light and filled with rising air bubbles. Here we have, in the first place, the method of superposition. The film was first exposed before an aquarium filled with fishes and plants; then the apparatus was set up in the "flies" of the theater with the lens pointing downward, as indicated in the diagram. Immediately under the lens the stage was covered with a gray cloth on which were painted marine plants, sea weeds, anemones, etc. The impersonator of the siren lies upon this cloth; turns, rolls over slowly, assuming attitudes and performing gestures appropriate to swimming and diving. The apparatus records upon the film, which already bears a series of pictures of the aquarium, all the motions of the swimmer. Many similar effects can be produced by placing the apparatus in the "flies." An automobile ascending a vertical wall is thus obtained, by running the car over a painted scene laid flat on the stage, and photographing it from above.

After obtaining, as I thought, a thorough education at the Gaumont establishment, I saw a picture which was a mystery to me. This represented a banquet which was consumed without the aid of guests. The viands simply disappeared. Wine glasses were filled from bottles held in invisible hands, a knife leaped through the air and sliced a sausage and a loaf of bread, several human hands performed various operations, etc. Many series of this sort have been shown recently. The operator to whom I applied for information smiled, shook his head, and said that these mysterious pictures were as great a puzzle to him as to myself, and that they were of American origin. He added that the Gaumonts had made a single picture of that general type, but he declined to give any explanation of it. I have seen the picture. It represents a workshop in which all the tools work without the aid of human hands. A plank rises from the floor, places itself upon the bench, is nailed, sawed, and otherwise treated by automatic tools.*

The makers of films are constantly vying with each other in new and surprising effects, and no man can say what the end will be. Already Gaumont's chronophone, an ingenious combination of the phonograph with moving pictures, makes it possible to see and hear simultaneously entire scenes of operas and plays.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from L'Illustration.

The Cologne Gazette, referring to the new agreement of the Porte with the Deutsche Bank for the continuation of the Baghdad line, states that the management of the railway remains exclusively in German hands. The period of the construction of the new section is not to exceed seven years. Curiously enough, the organ of the German Agrarians, the Deutsch Tageszeitung, denounces the Baghdad Railway project as a menace to German agriculturists. The Baghdad Railway, it says, will develop a new grain-producing country by which the interests of German farmers will be seriously affected.

* The dinner which was consumed without the aid of guests, the magic workshop in which a carpenter's tools saw wood and hammer planks without human aid, and similar effects are all of American origin. In the SCIENTIFIC AMERICAN we hope soon to explain how these photographic tricks are played.—Editor.

ARTIFICIAL ROCKS AND MINERALS.

AN IMPORTANT PHYSICAL STUDY.

BY PROF. A. MICHEL-LEVY.

THE first attempts at the synthesis of minerals date from the end of the eighteenth century. The method used was that of igneous fusion. Better results were obtained after the introduction of volatile and soluble fluxes. Thus, Ebelmen, in 1851, made many gems by fusion with borax and evaporation of the excess of the flux, and Hautefeuille obtained quartz and certain felspars in 1877. Still greater progress was made after the application of water under pressure, that is to say, at a temperature above the boiling point. In this way De Senarmont in 1851 first certainly performed the synthesis of quartz in the wet way and obtained, in sealed glass tubes heated in metal vessels, many ores, sulphides, etc.

In 1879, Friedel and Sarasin improved the apparatus by lining the steel tube with platinum. They first obtained simultaneously quartz and orthose, and also quartz and albite, by operating with aluminium silicate in presence of dilute solutions of alkaline silicates. It is probable that the temperature did not exceed 500 deg. C. (932 deg. F.).

To resume: in this first period the method of purely igneous fusion produced little result, save a crystalline appearance of some of the products. The use of volatile fluxes was successful in reproducing gems and apatites. With the use of non-volatile fluxes, which can be washed out, we come to the fertile experiments of Hautefeuille with alkaline tungstates.

Daubrée and Sainte-Claire Deville made use of melted or vaporized crystallizing agents. Some of the minerals found in tin mines were obtained in this way.

Finally, water under pressure in sealed tubes produced metallic sulphides, quartz, and felspar, between 250 and 450 deg. C. (662 and 842 deg. F.).

Between 1878 and 1881 Fouqué and I obtained by repeated fusions a series of plagioclase felspars and other minerals. For the determination of temperatures we made use of the melting points of the metals gold, silver, copper, iron, and platinum.

We come now to the recent researches, in particular those which the generosity of Mr. Carnegie has provided with a new and perfect equipment. The employment of the Moissan and other electric furnaces, the Seger tests, and the Le Chatelier platinum-rhodium couple give to the recent researches a precision which is increased by the photometric method of measuring high temperatures. The material of the furnace, instead of consisting merely of fire clay, now includes magnesia, corundum, and even zirconium. The Spezia pressure tubes are sometimes substituted for the Freidel tube. Of all the closed apparatus, the only one which can resist internal pressure at 1,000 deg. C. (1,832 deg. F.) is the crucible of platinum, with 10 per cent of iridium used by Fouqué and myself in 1891.

In 1905 Day and Allen published a monograph on the physical and chemical conditions governing the formation of the plagioclases, confirming our own earlier results. They conclude that the plagioclases probably form an isomorphic series. In 1906 (Amer. Jour. Sci., Vols. 21-22), two very interesting researches in the synthesis of the calcium silicates (wollastonites) were published by Allen and White, and Day and Shepherd, the optical measurements in both instances being made by E. Wright. Day and Shepherd gave a eutectic diagram analogous to those of alloys, the eutectic fusing points being represented by the ordinates of a curve, of which the abscissas correspond to the percentages of time in the compound. The curve shows two maxima and three minima. For example, the metasilicate containing 37 per cent of lime corresponds to a eutectic compound melting at 1,415 deg. C. (2,579 deg. F.). This is the fusing point of hexagonal pseudo-wollastonite, which remains stable down to about 1,200 deg. C. (2,192 deg. F.). Below this point the stable metasilicate is the natural monoclinic wollastonite, which is easily produced by a prolonged heating of the pseudo-wollastonite. The silicates of magnesia have also been studied by Allen, Wright, and Clement.

The memorable synthesis of the diamond by Moissan also deserves mention. The melting point of cast iron is comparatively low, 1,600 deg. C. (2,912 deg. F.), and carbon dissolves in iron, crystallizing out in the form of graphite on slow cooling. Diamonds should be produced at a temperature below that of the crystallization of graphite. Moissan's plan of plunging cast iron in water produced in addition a high interior pressure. The formation of the diamond in native and meteoric iron is analogous.

Fusion with the addition of fluxes has produced some very curious results in recent years. Doelter attributes crystallizing properties to very small quantities of alkaline fluorides and chlorides, phosphates, borates, and tungstates. In all cases these salts lower the melting points, and by their aid Doelter produced amphibole and the micas.

A striking confirmation of the powerful crystallizing action of certain fluxes in small quantity is furnished by the remarkable results obtained by M. Morozewicz in 1898. Beginning with the ingredients of a liparite containing 78 per cent of silica he added 1 per cent of tungstic acid and heated the mixture for fourteen days to between 800 and 1,000 deg. C. (1,472 and 1,832 deg. F.). Whitish and grayish yellow traces were produced. The former exhibited under the microscope little crystals of quartz; the second, fine laminæ of biotite. There were in addition spherolites and small crystals of sanidine; hence the three chief elements of granite were reproduced by the addition of 1 per cent of tungstic acid, at a temperature below 1,000 deg. C. (1,832 deg. F.)

Analogous with this is the synthesis of albite as performed by Hautefeuille and subsequently by Day and Allen. When the finely pulverized ingredients were heated with sodium tungstate to 1,100 deg. C. (2,012 deg. F.) for eight days, the only result was the formation of two glassy strata of different densities. When, however, the mixture was heated to 900 deg. C. (1,652 deg. F.) for seventeen days small crystals, having the density, chemical constitution, and optical properties of albite, were formed without fusion. Hence tungstic acid appears to act as a crystallizer rather than as a flux.

The employment of water under pressure has not been productive of equally interesting results in recent years. The reason is that we do not yet possess a vessel which will stand heating above 500 deg. C. (932 deg. F.) while filled with water under pressure. The only metal which will resist above a red heat is the platinum-iridium alloy, but this is very porous, and after a few hours permits highly compressed gases to escape. We have already alluded to our experiments of 1891. They proved that an acid mixture very finely pulverized becomes transformed at 1,000 deg. C. (1,832 deg. F.) by superficial formation of orthose. At the same time small particles of brown mica and spinel are formed. Quartz does not appear, but in none of our experiments did we find water remaining in the crucible. Some experiments made in 1904 suggest that acid glasses may be saturated with water under pressure at 800 deg. C. (1,472 deg. F.).

Spezia has made use of the solubility of silica in sodium silicate to obtain crystals of quartz, which dissolves in a 2 per cent solution of sodium silicate at 330 deg. C. (626 deg. F.) and crystallizes out at 230 deg. C. (446 deg. F.).

From the view-point of the history of the earth's crust, we may divide our results into five classes, according as they relate to: 1, eruptive igneous rocks; 2, fundamental igneous rocks; 3, the products of fumaroles and hot springs; 4, sedimentary rocks; 5, metamorphic rocks.

Igneous fusion alone appears to cover all the syntheses of the first group. Those of the second group are dependent upon the presence of water under pressure, although the most recent experiments have utilized also cements and fluxes which have a crystallizing action, for we must remember that the melting points of the minerals to be produced (felspar and quartz) must not be attained.

The third group makes use of volatile fluxes, and also of synthesis in sealed tubes under pressure. It includes the formation of petroleum and volcanic hydrocarbons, the origin of which Moissan has shown to be due to the decomposition by water of metallic carbides.

In the fourth group we must study the successive deposits from saline solutions: in lakes, alkaline chlorides, gypsum, etc.; in deeper waters calcium phosphates. More complex reactions account for dolomite in the vicinity of coral reefs.

Finally, the fifth group is the most copious of all. Here must be classed metamorphism by contact gradually passing to general metamorphism, as from mica schist to gneiss, and thence to granite. Everything indicates that the effective agent is a strong current of alkaline silicates at high pressure and temperature. The same group includes many other processes, such as the production of coal and other mineral fuels, the distillation of naphtha from fossil accumulations, the circulation of cold solutions of silica producing the chailles, and the sand of calcareous sediments, and finally a transformation by secondary actions of all these minerals under the influence of water. Mechanical actions must be added to other metamorphic agents, but it seems to be proven that pressure alone without heat cannot produce profound modifications.

The chemical, physical, and mineralogical problems suggested by these syntheses are as numerous and interesting as the geological ones. We have already seen that fusion, applied to the natural series of minerals, completed the data which we possess on the isomorphism of silicates, etc.

We shall see that the theory of eutectism permits us at least to estimate the order of formation of the principal elements of rocks, and to determine the quantities of the components associated in the form of eutectic structure; that is to say, of simultaneous crystallizatien.

The synthesis of rocks by fusion confirms the existence of two principal times of formation at different temperatures. Our plates of artificial basalt were obtained by two distinct heatings. The first, at above 1,500 deg. C. (2,732 deg. F.), gave only peridotite in large crystals. The second, at 1,300 deg. C. (2,372 deg. F.), produced microliths of labradorite and pyroxene in the interstices of these crystals. The examination of natural rocks confirms this view, the discrepancies being only apparent and readily explicable on the eutectic theory.

Practically, we have proved that too rapid heating after fusion usually produces only skeleton crystals. We observe, furthermore, that the new theory of the mutual solution of fused silicates in each other, and that of solid solutions, do away with the distinction between purely igneous fusion and fusion with fluxes or cements. In all these cases, in fact, the eutectic laws may be applied on a definite condition; namely, that the compounds pre-exist in solution. Now, our experiments show that this pre-existence demands heating to a suitable temperature, a little lower than the melting point of the mineral sought.

Quite recently, in 1903 and 1904, Vogt endeavored to combine all the applications of the eutectic theory that can be made to fused silicates, regarded as analogous to metallic alloys. It is probable that there are mixtures of eutectic silicates. I have always carefully noted every case of simultaneous (or pegmatoid) crystallization revealed by the microscope, and have discovered such associations of quartz with garnet, or those with biotite, and hornblende with plagioclase. In connection with the last-named observation I pointed out, in 1878, that the study of these simultaneous natural crystallizations of minerals which we experience great difficulty in producing separately in the laboratory may ultimately solve the problem of the genesis of rocks and the solvents associated with them in nature.

Hence, I am in principle an earnest advocate of the eutectic theory, but we must recognize, first, that eutectic combinations are rare both in nature and in products of synthesis; and secondly, that the lowering of the fusing point is very much less in these cases than in those of alloys. Vogt rarely found a greater diminution than 100 deg. C. (212 deg. F.) below the melting point of the most fusible of the constituents, and it is certain that, with the exception of a few exact determinations made by American scientists, we do not know the fusing points of minerals to this approximation.

Let us assume, as proved, the formation of eutectic combinations of silicates, and suppose that we have, in mutual contact, two substances, *A* and *B*, which are capable of forming a eutectic compound *ab* and which melt at the temperatures *Ta* and *Tb*, of which *Ta* is the higher. Then the greater the difference *Ta-Tb*, the greater will be the proportion of *B* in the eutectic compound *ab*, and the more closely will its fusing point (the eutectic point) approach *Tb*. On the other hand, the eutectic compound will contain equal proportions of *A* and *B* if their fusing points are the same. Hence, when a very hot magma cools slowly the constituent *A*, which has the higher melting point, is usually the first to separate. In this way the residual mixture becomes poorer in *A* and approaches to the composition *ab*. As a rule, however, the eutectic compound does not solidify *en masse* as soon as its fusing point is attained, but it becomes supersaturated with *B*, which then separates, and finally, under the influence of repeated shocks or

other causes, the compound *ab* may solidify *en masse*. Thus microliths of *B* may become imbedded in the still growing large crystals of *A*.

With few exceptions, *A* separates first. In zoned isomorphous crystals, of the plagioclases in particular, the heart is the least fusible part. Apparent exceptions to this law, however, may be produced by various causes. If the proportion of *A* in the original mixture is less than in the eutectic compound, *B* is the first to separate. Other exceptions, less easily explained, are due to supersaturation with alumina, the great viscosity of fused silica and some silicates (albite, orthose), the liberation of certain ions which displace others, according to Nernst's law, and the still mysterious action of tungstic acid, water under pressure, and other crystallizing agents.

The large crystals (phenocrystals) which occur in eruptive rocks and exhibit a zoned structure, have been formed, for the most part, before eruption, while the microliths of different composition which are partially imbedded in them, are of later formation. The large crystals of fundamental igneous rocks, on the contrary, have generally originated and developed *in situ*.

I have endeavored to give a succinct account of recent experiments in the synthesis of rocks and minerals. Notwithstanding the improvement in methods it appears that the acid rocks, granite and graphic pegmatite have resisted all efforts and we are little nearer their synthesis at the present time than we were in 1892.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Révue Générale des Sciences Pures et Appliquées.

ONE-HORNED AND THREE-HORNED SHEEP.

BIOLOGICAL CURIOSITIES.

BY HENRY SERFFAIT.

THE Himalaya region is the home of many zoological curiosities, among the strangest of which are the sheep which are found in Nepaul with an abnormal number of horns. Several specimens of this ovine species, *Ovis nahoor*, which is peculiar to Nepaul, were collected by the Prince of Wales during his last visit to India, and presented to the London Zoological Garden. The Nepaul sheep is a shy and small, but stoutly built, animal, and is found at elevations as great as 16,000 feet. The most remarkable peculiarity of the species is that the number of horns varies from one to four in animals of the same strain. In other words, the variability, but not the particular variation, is inherited. In the one-horned individuals the single horn is median, very broad and bent backward over the neck, giving the animal a very singular aspect (Fig. 1). The third horn of the three-horned sheep is placed behind one of the two normal horns (Fig. 2). Most remarkable of all are the four-horned sheep, which have a pair of short horns close above the eyes and a pair of much longer horns behind.

In other species of animals, sports or variations like these occur only at long intervals, and the particular variation is transmitted to the offspring, but in the Nepaul sheep they are of very common occurrence, and the progeny of one-horned parents, for example, may include animals with one, two, three, and four horns. The skull of a three-horned sheep of the common East Prussian breed, an example of individual mutation, is shown in Fig. 3. The Nepaul sheep, however, bid defiance to the current theory of mutation, and give a new insight into the variability of species.—Umschau.

FIG. 1.—NEPAUL SHEEP WITH ONE HORN.

REFRIGERATOR CARS.

A NEW refrigerating car, the design of two Liverpool experts, has been put upon the English market. The London Times, in describing it, says:

"Up to the present practically no improvement has been made in the ordinary iced box car for carrying perishable produce, a system which has decided limitations. The car now introduced accomplishes the cooling by means of a mechanical refrigeration plant, which consists of a small inclosed type ammonia compressor of special design mounted on one end of the car; an ammonia condenser designed for cooling by the air current produced by the motion of the car and placed on the roof; an expansion valve arranged to keep, automatically, a constant pressure in the evaporators within the car, and consequently a constant temperature therein, and ammonia evaporators placed in suitable positions inside the car arranged to provide a regular supply of cold to keep the car temperature constant during stoppages. The compressor is driven from one of the axles by chain gearing, a change speed gear and disengaging mechanism being interposed between the axle and compressor. The driving wheel placed on the axle may be arranged to allow the toothed part to swing in either direction, and thus keep in the same plane as the driven wheel on the intermediate shaft.

FIG. 2.—NEPAUL SHEEP WITH THREE HORNS.

"The advantages claimed for this type of car over those now in use are that it is independent of any ice supply whatever; it is available at any point on the line and at all times; it obviates delays due to icing, and, in addition, the expense attaching to ice storage and filling; it effects a lower temperature than is possible with ice tanks; it can undertake any length of journey without renewals; and it is free from the risks due to careless or insufficient icing."

CENSUS OF HIGH BUILDINGS.

A COUNT of the skyscrapers on Manhattan Island has been made, and it shows that 540 buildings of ten or more stories have been erected since 1890. Twelve stories is the favorite number above ten, apparently, for the Building Department's records show that 169 twelve-story structures have been built or are now under way. Maybe superstition partly explains the fact that there are only 13 thirteen-story buildings.

Less than a dozen years ago the American Surety Building at 100 Broadway, twenty stories high, was a world wonder. Never, people said, would it be eclipsed. Now it is insignificant compared to some others. The Singer rises forty-one stories and the Metropolitan Life, now under construction, will break the record with forty-eight.

Including the Metropolitan Life Building, which is not yet finished, the census of high buildings is as follows:

No. of Buildings.	Height.	
1	48	stories.
1	41	"
2	26	"
3	25	"
2	23	"
4	22	"
9	20	"
2	19	"
9	18	"
2	17	"
19	16	"
19	15	"
18	14	"
13	13	"
169	12	"
101	11	"
164	10	"

The discovery of the structural possibilities of steel is what did it. Modern fireproofing methods—protecting the steel with unburnable terra cotta, and using the same material for floors and partitions and inclosing elevator shafts and stairways—made the skyscrapers perfectly safe.

Washable Coating for Plaster Casts.—Coat the casts repeatedly with alcoholic solution of stearate of potash. Stearate of potash (soap) is thus prepared: 3 parts by weight of caustic potash are dissolved in 36 parts of hot water and 9 parts of stearic acid (stearine candles, prime quality) added. Stir well. When the mass assumes a glue-like consistency, add equal parts by weight of water and 95 per cent alcohol. The solution should be stood in warm water. The plaster casts, previously warmed, are given two or three coats of it, and after two to three hours, washed off with water and a sponge; if the water is clouded, give the casts after drying another coat of the potash soap solution, allow them to stand for 5 to 6 hours, then wash them.

THE ALGERIAN SAHARA.

THE remarkable progress that has been made by France in transforming the Sahara desert south of Algeria as far as it is capable of improvement is described by Mr. Jonnart. The events mentioned by him show fully the control that the French have acquired over the Sahara by training camels to such a degree of fleetness that the desert may now be crossed in all directions without the necessity of carrying more supplies than are needed from one oasis to another. The suppression of bandits has aided the possibility of this control, for these marauders can no longer spread terror over the desert owing to the ability of the French to catch and punish them. The policy of enlarging the oases by wholesale tapping of the underground water supplies has been initiated, thereby increasing the productiveness of the regions. Four territorial governments south of Algeria have been organized, and in each an administrative center established. Two of these territories reach far south of the localities where Colonel Flatters and Miss Tinné were murdered. Previously, white men ran enormous risks in traveling through the lower half of this stretch of country. An attempt has been made to count the desert inhabitants, and it is stated that there are about 450,000 of them in Tuggurt, the capital of which is Biskra, to the southern edge of the three other desert provinces. Many thousands of these people are newcomers, who have been drawn to this part of the Sahara because of the medical dispensaries, that have been opened at every post and station by the Algerian government where modern medical aid is given free.

There are also nine agencies among the oases that are suggesting and carrying out measures for improving the general condition. After a recent bad crop season, for example, they provided a supply of grain for planting. Usurious rates of interest have to some extent been reformed, and forty-three elementary schools have been opened, in which, together with a little book learning, the pupils are taught the use of the simpler implements, and conveniences of civilization, the best methods of tilling the soil, and sufficient French for conversational purposes.

FIG. 3.—SKULL OF THREE-HORNED PRUSSIAN SHEEP.

WEISMANNISM.*

A SCIENTIFIC THEORY OF HEREDITY.

BY M. A. LANE, MEMBER AMERICAN MICROSCOPICAL SOCIETY.

WE may classify Weismann as one of the men who have made epochs not only because his ideas made more talk than those of any other man save Darwin, but because these ideas are already having their effect upon all sound considerations of social welfare and progress, and will probably have a more far reaching influence upon social and political history than that of all the soldiers and statesmen of the world put together.

Weismann, like Darwin, was seeking to solve the mystery of organic evolution. He had no notion of the vast social and political importance hidden away in his fascinating theory, just as Darwin had no notion that his "struggle for life" would be expanded into a "struggle for existence" as wide as the universe itself and operating in the world of so-called dead as well as of living matter. Weismann not only cut away one-half of the complicated machinery which Darwin had constructed to account for evolution, but he inadvertently opened up a view of man and society which forces us to reconsider all the old convictions we have had concerning the possibilities that may lie in the savage and in civilized man, and the parts they are to play in the future of human affairs.

Weismann sums up his entire theory and its corollaries in the phrase, "The continuity of the Germ-Plasm." These suggestive and alluring terms can be understood by a brief examination of the simpler details of the reproduction of the lowest forms of plant and animal life as they are revealed by the microscope. It was the observation of these facts that first suggested to Weismann the basis of his remarkable theory which is an application to man and other higher organisms of the established fact that the individuals of the lowest forms of life are immortal. Man's body itself is not immortal, but a part of his body is immortal, and this part—what Weismann calls the germ-plasm—is handed down immortal and continuous, from generation to generation, unbroken and unchanged—except in certain circumstances—by the adventures of the body itself in the surroundings, or environment, in which it lives. How true this immortality is will be seen in the method by which the simplest forms of life reproduce themselves.

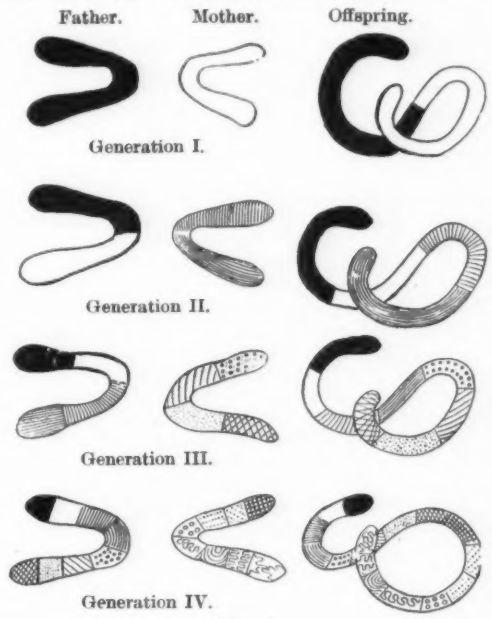


FIG. 4.

Diagram showing how the units of the heredity-substance, the germ-plasm, grow more complex with succeeding generations. (From Weismann's Essays.)

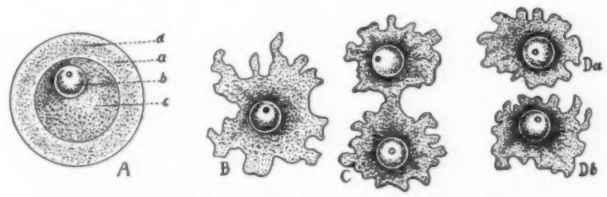


FIG. 1.—REPRODUCTION OF A CELL, AMŒBA.

Highly magnified. (Haeckel.) A. The cell in its capsule *d*. The cell-body *c* encloses the nucleus *b* and this encloses the nucleolus, or germ-speck *a*. B. The cell has burst through its capsule. C. The nucleus has divided into two nuclei and the cell body is pinched in the middle. D. The division is completed by the cell body falling into two equal halves, making two new cells *Da* and *Db*.

The lowest form of life—man being considered the highest—is found in races of microscopic animals and plants which consist of a single cell. Fig. 1 shows an animal, a species of amœba, highly magnified, in the different stages of its reproduction. The animal consists of a tiny lump of jelly-like, semi-fluid matter, which, in a state of rest, is spherical. It is surrounded by a capsule and inclosed within it is another spherical body, the nucleus, and within this still another little body called the germ-speck, or nucleolus. The animal, by means of finger-like processes which it shoots out from the substance of its body, crawls about the weeds in ponds, and feeds on various kinds of nutr tious substances. It grows large, and when it reaches a certain size the capsule bursts and the animal escapes. The nucleus then divides, and each half withdraws to opposite poles of the cell. The cell body itself constricts in the middle and is cut in two. There are now two cells instead of one, two amœbæ instead of one. But each new amœba is actually a part of the parent—one-half of the parent. The parent does not beget two children, and then die. It becomes itself two—multiplies itself by two, and so on without end.

What causes the little nucleus to divide and then, later, the cell body itself? There must be some mechanism for this remarkably equal and orderly division of the cell. Then, too, it is clear, that in this perfectly equal division each daughter cell is obviously like the parent, if the parent was divided into two perfectly similar parts. The begetting of like by like is here an obvious necessity. How could it be otherwise—if the halves are just alike? Inheritance here, in this little cell, is not precisely a question of *transmission*, but of *division*.

Let us fancy now that when a cell divides, the daughter cells do not separate and go on living as independent individuals, as amœbæ do, but that they remain stuck together by a kind of cement, or other substance, manufactured by themselves; that the division of the cells takes place innumerable times; the new cells being held together—and that the cells, as they multiply by the billion, are changed in their form, so that in this growing organism one group of cells is built up into one organ or tissue, another group into another, until ultimately this single cell has grown into a great cosmos of cells—why then, we would have a *multicellular* animal such as a frog or a man; or, if the cell were a plant-cell, a multicellular plant, such as an orange tree or a rose bush. That such is really the case with all animals and plants can easily be proved by making a very thin slice of any animal or plant tissue and examining it in a compound microscope. Such a slice, or section, is shown in Fig. 2, which is an excellent picture of the sight one sees when one examines an extremely thin section cut from the tip of a growing onion root. Here we see the cells bound together, each with its nucleus and germ-speck (sometimes two germ-specks), the drawing representing, of course, not entire cells, but very thin sections of cells. And when one considers that this drawing presents but the merest invisible fragment of the tip of the onion root, one can form an idea of the incalculable number of cells in the whole plant. Here and there in the drawing is seen a cell in which the nucleus is replaced by odd-looking black, curved rods, or loops, which seem strung upon a spindle-shaped structure made up of thin threads. These little threads are the mechanism by which the nucleus and cell are divided, and these cells are in process of division. We can see here, by means of the special technique used, what takes place in the cell when it divides like the amœba in Fig. 1.

To understand Weismann's views of inheritance it is necessary to state a few more of the simpler details of cell division which is at the bottom not only of the mysterious facts of inheritance, but which is also the fundamental fact of organic evolution, and for the most part of vital growth itself. The nucleus of every cell is made up of a delicate network called *chromatin*, because it is quickly and permanently colored by certain ordinary dye-colors which do not stain the rest of the cell. The conduct of this net-

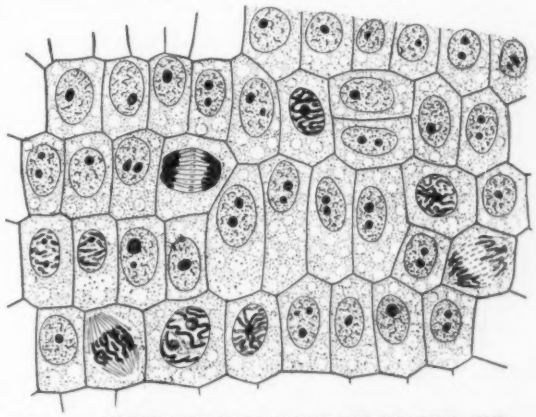


FIG. 2.—VERY THIN SECTION FROM THE TIP OF A GROWING ONION ROOT, SHOWING HOW THE CELLS OF MULTICELLULAR ORGANISM ARE BOUND TOGETHER.

Highly magnified. Several of these cells are in process of self-division. (From Wilson's "The Cell.")

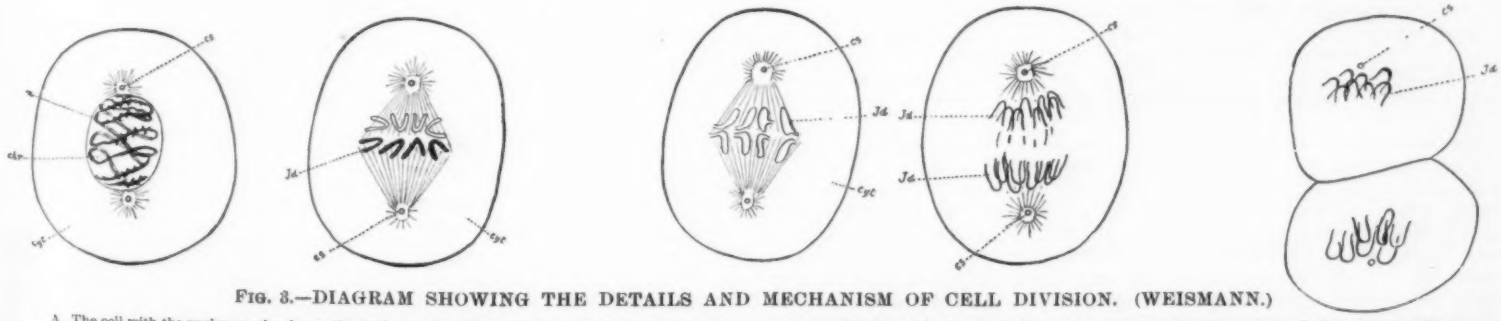


FIG. 3.—DIAGRAM SHOWING THE DETAILS AND MECHANISM OF CELL DIVISION. (WEISMANN.)

A. The cell with the nucleus *n*, the chromatin *chr* loosened and formed into a spiral. The centrosomes *cs* have appeared in the cell-body *cyt*. B. The nuclear membrane has disappeared. Delicate threads radiate from the centrosomes and have laid hold of the loops, or rods, or chromosomes *Jd* into which the chromatin has broken up. C. The rods have split longitudinally and the threads are about to pull them apart. (Only eight of the sixteen new rods are shown for the sake of clearness.) D. The daughter rods are being pulled to opposite ends of the cell. E. The cell has divided and each new cell contains half of the new rods into which the chromatin split.

* Abstracted from Uncle Remus's Magazine.

work of chromatin is very curious during the division of the cell, so much so that it gives us clear evidence of the existence of a special and highly complex mechanism by which the cell is pulled in two, as one pulls a piece of soft candy into two equal parts.

When the cell is ready to divide there appears at either side of the nucleus a small body surrounded by thread-like radiations, called the *centrosome*. The network in the nucleus becomes thickened and loosened. This is shown in diagram *A* of Fig. 3. The next step is shown in diagram *B* of the same figure. The network has broken up into eight horse-shoe-shaped rods, and the threads from the centrosomes have approached the rods so as to form a kind of spindle. In diagram *C* the rods have split longitudinally and are about to be drawn apart by the threads of the spindle. In *D* each centrosome, by means of the threads, has drawn eight of the sixteen new rods toward itself to opposite ends of the cell. In diagram *E* the cell is shown divided in the middle, each new cell having half of the split rods of chromatin in its center. The nucleus in each new cell is now reformed as in diagram *A*, acquires a membrane, and the division is complete.

All cells normally divide in this manner, and all higher animals are formed by the repeated division and differentiation of cells which come originally from the division, in a similar manner, of the egg, which is itself a simple cell the size of which is made more or less large by the accumulation of yolk or food-stuffs in the cell body around the nucleus. The egg-cell by dividing into two, four, eight, sixteen, thirty-two, sixty-four and so on, doubling the number with each quick division, soon becomes a vast colony of cells, thus building up the body with all its various tissues which are themselves composed of cells and their products. The new animal, thus produced, in its turn produces eggs which again, by multiplication, grow into new animals just like their parents. This has been demonstrated again and again by the observation of the developing eggs of numerous animals, principally the hen, while the principal facts of cell division have been demonstrated again and again by careful observation and experiment upon the eggs and other cells of various animals and plants.

These facts warrant the conclusion that the chromatin in the nucleus of the egg-cell is the basis of inheritance, that the destiny of the organism depends upon the nature of and the laws governing these minute, microscopic bodies, and that all the inherited characters of the full grown animal—be it man or other—are potentially contained within these little rods which may measure no more than say one-fifty-thousandth of an inch in length.

These facts and these assumptions were still in the making when Weismann announced his theory in 1885, and it is noteworthy that some of his predictions, one may call them, have been verified by microscopic observation. Granting that the chromatin of the nucleus is the basis of heredity, Weismann assumes that these little rods, small as they are, are very composite bodies, made up of units which are themselves made up of units still smaller, and that these units of the second order are composed of yet smaller units of a third order while these again are composed of units of a fourth order—which he calls *biophors*, or life-bearers. These inconceivably small units—the life-bearers—are capable of growth and multiplication, as are also the units of each succeeding order, up to the chromatin rods themselves. And Weismann further holds that in the dividing egg the halves of the split rods, while equal in number, are *unlike in kind*. This makes it possible for successive generations of cells to vary more and more in form until, at maturity of the animal, the countless descendants of the original egg-cell are all highly different from their common ancestor, with the exception of certain cells which are destined in the future to reproduce new germ-cells which will contain the original stuff—the germ plasm—unchanged. These germ-cells contain the potent matter which, in this inconceivably minute form, carry down the immortal life-bearers from generation to generation as an inviolable legacy which all parents hold in trust for their children, but which they cannot take from or add to by any conceivable conduct of their own. The individual is thus made up of two kinds of cells—the cells of which its body is composed—a great race which lives for a season and dies—and the cells which contain the potent heredity-stuff, the legacy that the individual holds in trust and passes down, unaffected by the individual, to his offspring—the immortal part of life. This conception, vast and magnificent as it is, is Weismann's contribution to science. His chief merit is that of having anticipated a number of epoch-making discoveries in the reproductive physiology of the cell; of having stimulated the researches which led to those discoveries, and of having united upon a common basis the great development theory of Darwin and the marvelous cell theory of Theodor Schwann. He has made evolution intelligible by the light of the cell, and the cell intelligible by the light of evolution. For by this theory we can rid the conception of organic evolution of the entire cumbersome machinery of the transmission of acquired characters, the whole stress being confined to natural selection and to variation produced by the mixing of germ-plasms of different individuals—what Weismann calls *amphimixis*. Weismann has constructed a most ingenious diagram to show how generation after generation can develop new characters until an individual is produced as different from its ancestors as a man differs from an ape or a reptile. This diagram is reproduced in Fig. 4. The drawings, of course, do not represent a real animal, but only go to show how successive mixtures of the constituent bodies of two different germ-plasms would produce a germ-plasm in four generations immeasurably more complex than that of the first generation. In the first generation the mixture of the black and white naturally produces a black and white germ-plasm. In the second generation this two-fold germ plasm, uniting with another and a different two-fold germ-plasm, produces a four-fold offspring, and so on, so that the last offspring has sixteen times as many units of the third order as either the father or the mother in the first generation. This multiplication of characters in succeeding generations is not due to the transmission to offspring of characters acquired by the parents, but is due to the simple mixing of the different units possessed by different individuals and passed down by them to their offspring. Organisms having characters favorable for survival continue to live and propagate while those not so favored are eliminated and disappear from the list of living races.

ACETYLENE.*

ITS PRESENT COMMERCIAL STATUS.

BY A. CRESSY MORRISON.

ACETYLENE is so largely used throughout the world that it is generally recognized as one of the common illuminants. Any illuminant which candle power for candle power and cost for cost compares favorably with city gas at a dollar a thousand cubic feet, and which can be generated by an inexpensive individual apparatus, commands serious consideration. When it can be said in addition that it is the nearest approach to sunlight yet attained, then C_2H_2 is destined by inherent merit to win and hold a conspicuous place.

In March, 1836, Edmund Davey, professor of chemistry to the Royal Dublin Society, described the properties of a new gas, C_2H_2, and followed this in the autumn of the same year by a more extended paper to the British Association, closing the report with the following remarkable statement: "From the brilliancy with which the new gas burns in contact with the atmosphere, it is, in the opinion of the author, admirably adapted for the purpose of artificial light, if it can be produced at a cheap rate." Scarcely a year passed without some step being taken which elucidated the physical and chemical properties, and a list of those who contributed to our knowledge of the subject would embrace many of the greatest names in chemistry and physics. An unusual condition surrounds the birth of this interesting gas, in that, long before its production on a commercial scale seemed possible, its properties were thoroughly understood, its place in nature had been ascertained, and its field of utility anticipated.

With the extraordinary progress of electrical science, came the development of the electrical furnace, by the use of which, in the spring of 1892, Thomas L. Willson produced calcium carbide by the combination of lime and carbon in the terrific temperature of the electric arc. On September 16, 1892, Willson sent specimens of his carbide to Lord Kelvin. Later, Moissan, working in France, also produced calcium carbide.

Calcium carbide is a substance resembling dark granite, running in various sizes (according to the use to which it is to be put) from egg size coal to the size usually known as pea. The component parts are lime and carbon. Coke, as a typical carbon, is largely used in the production of calcium carbide. The lime must be pure and practically free from some of the usual constituents of lime. The lime and carbon are crushed very fine, mixed in proper proportions, and, in a specially constructed furnace, subjected to the heat of an electric arc. The amount of electric horse-power required for the production of calcium carbide varies, but it has been stated that it takes a horse-power year to produce a ton. Under the best conditions, a horse-power year will produce somewhat in excess of this quantity.

When the lime and coke are subjected to enormous temperature, said to be above 5,000 deg. F., they combine and are removed from the furnace either by tapping, when the molten material runs into molds, or in a species of rotary furnace the calcium carbide, still hot, is removed in pigs weighing a thousand pounds or more. These are broken by sledge hammers, run through crushers, packed in sheet steel drums, and, for domestic use, distributed one hundred pounds to the drum.

When calcium carbide is placed in water, the affinity of the calcium manifests itself, and the carbon is set free. The carbon immediately forms a combination with the hydrogen of the water, in the form of C_2H_2, which is acetylene.

Theoretically, one pound of calcium carbide will liberate somewhat over five cubic feet of acetylene; in practice the yield is about five cubic feet to the pound.

With the birth of calcium carbide as a commercial product, there arose a series of scientific investigations that the best practical methods of utilizing the new illuminant might be found. The process of generating acetylene being so simple, the field opened was a very promising one. While the physical characteristics of acetylene had early been studied, its use for domestic or industrial purposes brought into play conditions hitherto unconsidered.

Acetylene when compressed to liquefaction, occupies but one-four-hundredth of its bulk at atmospheric pressure. The most obvious course of procedure was, therefore, the compression of acetylene into cylinders, and its release under pressure regulators, to be utilized at the burner as required. It was found, however, that acetylene when compressed gradually changed its nature, and under heavy pressure became a very dangerous substance. Explosions followed the experiments, and as a result compressed liquefied acetylene is no longer utilized.

Some years were to elapse before a means could be devised for the utilization of acetylene in compressed cylinders with safety. It was subsequently found, however, that acetone, a liquid related to alcohol, would at atmospheric pressure absorb about twenty-five times its bulk of acetylene, and for each additional atmosphere would take up an equal quantity. It was also found by filling the cylinders with asbestos, in the form of disks, that while the entire space was apparently occupied, as a matter of fact eighty per cent of the space still remained. It is a well-known property of gases that they will not explode through apertures of varying sizes, and in the case of acetylene no explosion will transmit itself through a minute aperture.

By exhausting the air from the asbestos in the cylinder and filling the vacuum thus caused with a certain percentage of acetone, it was discovered that an enormous quantity of acetylene could be stored in these cylinders at pressures not exceeding ten atmospheres, and that such cylinders could be subjected to all ordinary and some extraordinary tests with no danger whatever.

This system has been so developed that acetylene is rapidly replacing other illuminants upon railroads and in yacht lighting, and a conspicuous illustration of the utilization of acetylene on this principle is in the headlights of locomotives and automobiles, a field in which acetylene is rapidly extending.

While these uses of acetylene are interesting, its real use throughout the world is in domestic and business illumination, either by means of individual generators or by means of central town plants. There are domestic plants in operation in the United States exceeding one hundred thousand individual units. The number of towns lighted by central acetylene

* Abstracted from a paper read before the Illuminating Engineering Society.

plants is two hundred and ninety. The development of acetylene for domestic uses was attended by difficulties that were little expected, but adequate automatic safety devices have been developed, which bring this means of domestic illumination to a point of automatic simplicity greater than that of any other illuminant.

Acetylene's illuminating power is fully ten times that of city gas. Reduced to practical figures, a half-foot burner supplied by acetylene will give greater illumination than a five-foot burner supplied by city gas. The quality of the illumination is unequaled. The spectrum of acetylene is nearer to the spectrum of the sun than any illuminant; so close, indeed, that there is little prospect of further improvement.

The present price of calcium carbide in the United States is seventy dollars per ton. At this price, candle power for candle power, acetylene is cheaper than most illuminants. It compares with city gas at one dollar per thousand cubic feet, and so closely approximates kerosene in cost, that, when the trouble of lamp cleaning, chimneys, wicks, etc., is taken into consideration, it is really an economy here.

Acetylene represents the first step beyond kerosene for the country dweller. It is as great a leap in the direction of progress from kerosene as kerosene was from whale oil.

The industry has been developed to a point where the production of calcium carbide is definitely assured. The quantity which can be produced depends only upon the development of water power. The methods of generation and utilization have passed through their evolution, and the burner, which for a long period presented many problems, has now been perfected, so that the rich gas can be burned without danger of carbonization.

The time is ripe for a thorough and careful consideration of the problem of obtaining the maximum perfect illumination.

The first consideration should, I think, be given to the quality of radiance. Every illuminant has its special field of utility which no other illuminant can fill. Therefore, as a starting point, permit me to call attention to the fact that color values are normal under acetylene. Sunlight possesses practically the same candle power for each of the primary colors of the spectrum. That is, if a seven-candle power beam of sunlight is broken up into its constituents, we would have practically one candle power for each of the seven primary colors. The same would be true of a given candle power of acetylene. This balanced spectrum is a property not possessed by any other artificial light.

It must, therefore, be apparent that acetylene has a special field where fine discrimination in color values is necessary. There is scarcely an industrial institution where, in some stage of the process, a thoroughly trained eye is not called upon to judge color. In dye works, printing establishments, lithographers, paint grinding, carpet mills, in testing syrups and molasses, and in thousands of other ways acetylene is as clearly indicated as is quinine when malaria is diagnosed by the physician. Carrying this thought further it will be seen that in the operating rooms of hospitals, in the chemist's laboratory, in the laboratory of the physiologist, in the physician's home, and in many other places acetylene has a field practically its own.

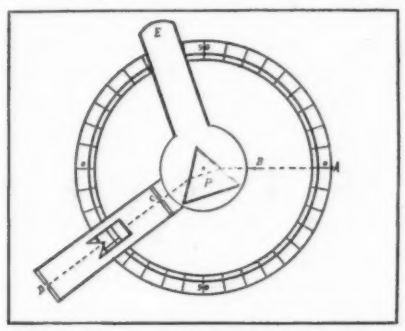
The optician is to-day called upon to diagnose abnormal conditions of the eyes, using abnormal light. It is a wonder that his work is so accurate. Here, too, acetylene will ultimately come into play. The artists of the world select a north light and paint by daylight. Their color values are thus balanced in accordance with the solar spectrum. Their paintings may be judged by the experts, and the medals awarded, in daylight, but the paintings of the world are judged by the great buying public usually under artificial light. We shall do well to consider the value of acetylene in public and private art galleries. The art connoisseurs will certainly appreciate the perfectly apparent fact that their millions of dollars worth of paintings can be made to look as well by night as by day, provided they invest a few hundred dollars in the purchase of special apparatus to produce an illuminant which is in reality daylight at night.

The illuminating engineer is to-day discussing with all seriousness the effect upon the eye, the optic nerve, and in fact dealing with the psychology of glaring lights; and the modification of brilliant units is being carried forward by them on the road to perfection. Acetylene is a brilliant unit, and it too will require modification. While its effect upon the eye, candle power for candle power, is infinitely less injurious than any other illuminant, it is as unwise to look acetylene in the eye, so to speak, as it is to gaze at the sun. On the other hand, it is literally sunlight, and it cannot be denied that through all the ages the eye of man has been modified to see best by the illumination from Old Sol. This constitutes a harmony of physical adjustment which gives acetylene an immense advantage which the illuminating engineers cannot overlook.

Acetylene is perhaps stronger in actinic or chemical rays than any other illuminant. The illuminating engineer will, therefore, at once recognize its great utility in photography. While the photographic studios of the world are to-day using artificial illuminants more and more, the actual amount of acetylene used for such purposes is not great, though it is more economical than the illuminants which it would replace.

This, however, while constituting a large field, is supplemented by a still larger practical utility, and that is in the photo-engraving processes, including the three-color printing field. Many photo-engravers are obliged to work day and night by artificial illumination, and the methods now in use are expensive and cumbersome compared with acetylene. In every phase of this industry the illuminating engineer will find that acetylene can be used with economic and practical advantages.

Acetylene has been very prominently mentioned for use as a standard for illumination. While there are many standards in use there is no satisfactory unit of light. The basis of all illumination is the light emitted by a sperm candle. This has a number of disadvantages which have never been entirely overcome. Before the science of illumination had reached its present stage of development and people were satisfied with low candle power lights of red color, and were not particular as to the amount, the candle was a very fair standard. At the present day the amount of light has changed until the unit of light is nearer 50 candles than one (having all due respect for the 16-candle power unit of the electrical people). The one-candle standard is still, however, adhered to—an arc light 1,000 or more candle power is still compared to the light of the sperm candle. With the increase in the volume of light its color has changed and now artificial light is very much whiter than was formerly the case. This lends another objection to the candle as a standard, as it is hard to compare the intensity of a white light—such as the arc lamp or incandescent—with the red light of an English candle. The German



APPARATUS FOR MEASURING THE INDEX OF REFRACTION.

standard, or Hofner candle, possesses disadvantages in an even greater degree, as that standard is only 88/100 of an English candle, and is still redder in color. Another difficulty with the candle is its susceptibility to drafts and to ventilation, and being made of spermaceti, which is an animal product, there is no assurance that any two candles will be similar, and that they will not suffer deterioration with time.

A really satisfactory standard of light should possess a large candle power, should be white, should be capable of reproduction by different men at different places, and the standard should be consistent with itself. There is no substance which lends itself to the fulfillment of these conditions better than acetylene. Its color is white, a one-foot acetylene flame will easily have a value of 40 candles, the acetylene is produced from a mineral product, which is not subject to decay or deterioration. Acetylene being a definite chemical compound without an admixture of any sort can be produced in a state of chemical purity which would give the same light wherever and whenever the simple conditions necessary for its production were provided. A screen with a hole so arranged that only the central portion of the flame would shine through, thus cutting off the edges and eliminating the error which might arise from different consumptions of gas, could be easily arranged.

The use of acetylene and calcium carbide in other fields is not without great interest to the illuminating engineer. The Canadian government has begun the substitution of acetylene for lighting all its buoys, lighthouses and beacons. It possesses qualities of steadiness, the possibility of burning for months without attention in inaccessible localities, and, it is said, a penetrating power in the case of fog that is unparalleled. With the light steadily burning, it is said that the heat of the generation of acetylene is sufficient to protect the generator against freezing, and acetylene in cylinders compressed in acetone and asbestos suffers no change under the lowest temperatures recorded. The United States government has already adopted acetylene for many lighthouses and for many beacons, and is now considering its rapid extension.

It has been found that acetylene headlights are an actual economy and a great advantage to long-distance trolley lines, and acetylene is now being substituted by such lines for the arc light headlight. Acetylene in this situation has the advantage of burning steadily, whereas, whenever the electric current is cut off, the trolley is left in darkness, and may run for a long distance at great speed without illumination.

The railroad systems are considering the use of acetylene for signals. The penetrating quality of the light in case of fog is here a matter of grave moment, and will be noted by the engineers.

The use of acetylene in power has been suggested, and has recently received a great stimulus by the enactments of the United States government relating to denatured alcohol. It is found that denatured alcohol containing twenty per cent of water, if atomized and blown through calcium carbide, will take up enough acetylene to enliven the alcohol and bring it up to the exact standard required for internal combustion engines. Engines using this power have been run for long periods of time, and the success of the process has been practically demonstrated.

A combination of acetylene and oxygen under about one-half atmospheric pressure, used through a blowpipe, produces the highest temperature known to chemistry—a temperature approximating that of an electric arc, probably above 6,000 deg. F.

The flame can be produced not larger than a pencil point, and through its means welding is successfully accomplished by literally melting the metal together. It is said that the use of this acetylene flame for cutting the steel girders and wreckage which resulted from the San Francisco fire would have saved millions of dollars. Great steel bridge girders can be melted apart with east and facility. It is said that a fourteen-inch shaft has been welded. Where the metal is so welded, the file fails to disclose the location of the break. There is scarcely a repair shop or metal-working establishment in the world which will not ultimately use many autogenous welding torches combining acetylene and oxygen.

The production of cyanamid, which is destined ultimately to supersede Chilean nitrates as a fertilizer, is now in practical operation in several countries. The exhaustion of the soil by the extraction of the nitrates by food plants is taking place so rapidly that, without a source of soluble nitrogen, the world would ultimately be confronted with starvation. The importation of Chilean nitrates during the past year has exceeded fifteen million dollars in value. The exhaustion of the Chilean nitrate bodies, from which a million and a half tons are now removed annually, is dated variously at from ten to thirty years from the present time. No other source of supply is known.

Four-fifths of the atmosphere is nitrogen. By blowing nitrogen through hot calcium carbide, the nitrogen is caught, and in such form that after various chemical processes it can be utilized in cyanamid. Experiments have shown that cyanamid possesses the same qualities as Chilean nitrates and can be used with equal success. The cost of production is such that it can be sold in competition with the natural product.

SIMPLE APPARATUS FOR MEASURING THE INDEX OF REFRACTION.*

By F. R. GORTON.

A CONVENIENT apparatus for the measurement of the index of refraction of glass is shown in the accompanying figure. The device consists of a one-half inch board about 8 x 10 inches upon which is mounted a graduated scale. About the center turn of the scale two arms made of thin brass and having the same shape except at the outer ends. Arm *E*, upon which a prism is to be centrally mounted, is provided with a pivot made by soldering a small wire nail at the exact center of the circle. The pivot passes through a hole in the second arm *DC*. This arm is provided with two sights *D* and *C* and an index placed precisely in the line joining the sights. *A* and *B* are two pins placed upon the radius drawn to the zero of the scale.

In order to measure the angle of least deviation, the prism is rotated by means of the arm *E* until the well-known effect for least deviation is obtained, after which the sights *D* and *C* are turned in line with the images of the two pins. The angle is then read directly from the position of the index on the scale.

In order to measure the angle of the prism, two small mirrors are attached to the refracting surfaces by means of a rubber band between the normals to which the angle is easily found. The arm *E* is first turned until *A* and *B* are in line with their images in one mirror and then the sight arm is rotated until the sights are in a normal to the other. The angle of the prism is then read directly from the index.

With little modification the apparatus can be used in determining the law of reflection of light. This is done by removing the prism and mounting a thin plane mirror precisely over the center of the scale and providing arm *E* with an index similar to that of the sight-arm. Of course the mirror must be mounted normal to a line joining this index with the center of the scale.

* School Science and Mathematics.

SCIENCE NOTES.

Prof. J. Hartmann describes the conclusions he has been able to formulate from his recent observations of the body now representing Nova Persei. For this work he designed a new spectroscope having a collimator objective of 40 millimeters aperture and 60 centimeters focal length, made of ultraviolet glass, two right and left handed quartz half-prisms of 30 deg., and a camera objective of quartz, 40 millimeters aperture and 32 centimeters focal length. With this apparatus attached to the 80-centimeter refractory he obtained an excellent photograph of the Nova spectrum on October 15 and 18, 1907, with a total exposure of 8¼ hours, the magnitude of the star being 11.4. The spectrum obtained was found to be very similar to that of the Wolf Rayet star B.D. 35 deg. 4,001. The line λ 4,688 is the strongest in both spectra, while the fairly strong Wolf Rayet line λ 4,618 is comparatively faint in the Nova. The nebula lines, which were very strong during the first part of the period of decline, are now very faint or absent.—Astronomische Nachrichten Bd. 177 No. 4,232, February 8, 1908.

There are upward of 70 species of edible seaweeds growing on the coasts of Hawaii, and about 40 of these are in common use by the natives. Seeing that Japan derives a large income from the economic utilization of its algæ, it is suggested by Mr. M. Reed, of the Hawaiian Agricultural Experimental Station, that the edible seaweeds of Hawaii might be used in like manner as the raw material for the manufacture of gelatine, glue, starch, etc. At present the algæ, which are known locally as *limu*, are only cultivated in a crude fashion, and are chiefly used in the form of salads. They contain a large proportion of phosphates, chlorides, bromides, and iodides, and are rich in starch and other carbohydrates. Three typical species examined by Mr. R. A. Duncan, contained, when dried by exposure to the air, 12.8 to 18.7 per cent of water, 5.6 to 14.87 per cent of proteins (gelatine), etc., 50.8 to 61.4 per cent of carbohydrates, 0.19 to 2.98 per cent of crude fiber, and 15.6 to 17.8 per cent of mineral constituents. Experiments showed that these *limus* yielded satisfactory preparations of commercial glue and gelatine.

The great achievement of France in forestry has been the establishment of protective forests where much destruction had been caused by floods and winds. From various causes large areas were cleared of forests toward the close of the eighteenth century, and only when it was too late was it realized that these lands were not fit for agriculture and should have been left in forest. To repair the mistake, a movement to reforest began in the nineteenth century. It was an exceedingly expensive mistake. Down to the present time, encouraged by wise laws, the State, the communes, and private landowners have restored to forest over 2,500,000 acres, and so saved them from ruin. In addition, the resulting forests return an excellent revenue. Two-thirds of the torrents of Europe are in France. In the Alps, the Cevennes, and the Pyrenees mountains there are 1,462 brooks and mountain streams which are considered dangerous. Nearly a million acres of mountain slopes are exposed to erosion by these streams, to say nothing of the flat land below. As far back as the sixteenth century there were local restrictions against clearing mountain sides, enforced by fines, confiscation, and corporal punishment. In the main these prevented ruinous stripping of hillsides, but with the French Revolution these restrictions were swept aside and the mountains were cleared at such a rate that disastrous effects were felt within ten years. By 1803 the people had become aroused to the folly of this cutting. Where useful brooks had been there now rushed torrents which flooded the fertile fields and covered them with sterile soil washed down from the mountains. The clearing continued unchecked until some 800,000 acres of farm land had been ruined or seriously injured, and the population of eighteen departments had been reduced to poverty and forced to emigrate. By 1860 the State took up the problem, but in such a way that the burden of expense for reforestation was thrown upon the mountaineers, who, moreover, were deprived of much pasturage. Complaints naturally arose. An attempt was made to check torrents by sodding instead of by forest planting. This, however, proved a failure, and recourse was again had to planting, by the law of 1882, which provides that the state shall bear the costs. Since then the excellent results of planting have completely changed public sentiment. The mountaineers are most eager to have the work go on and are ready to offer their land for nothing to the forest department. In addition to lands secured by gift, the state acquires 25,000 or 30,000 acres a year. Over 500,000 acres have been acquired and more than one-half of this area has been planted. Already 163 of the torrents have been entirely controlled and 654 are beginning to show the controlling effects of the forest on their watersheds. Thirty-one of the torrents now entirely controlled were considered hopelessly bad half a century ago. It is expected that $50,000,000 will have been spent before the work of reforesting for protection is complete.

ENGINEERING NOTES.

The traffic problem in Berlin has become so acute that the town council has voted $20,000 as a prize for the best plan of laying out future additions to the city with a view of distributing the traffic. The congestion is particularly acute in the Leipzigerstrasse, and plans are being considered for diverting cars and vehicles to parallel streets. It is also proposed to tunnel under the Potsdamer Bahnhof, which cuts off communication between busy parts of the town.

A large tower crane carrying a jib of 53 feet radius 93 feet above the ground has been erected in the Bremer Vulkan shipbuilding yard at Vegesack, Germany. The tower has a rectangular cross section and runs on rails of 20 feet gage. The distance between the trucks under the tower legs on each side is 26½ feet. The jib crane is carried near the top of the tower by guys running from the top. The crane has a lifting capacity of 3 tons at a radius of 53 feet or 6 tons at a radius of 30 feet.

To learn how much of convenience and cost saving can be secured to the maintenance of way department from a portable blacksmith shop, M. L. Byers, chief engineer of maintenance of way of the Missouri Pacific, last fall had an outfit arranged for this purpose. It consisted of two box cars, one housing the blacksmith and his helper, and the other the shop. The latter included a forge, and the necessary tools, duplicate parts and supplies needed for repairing hand cars, frogs, switches, tools, etc. The outfit is moved by local freight trains. About one day is needed to do up the work of an ordinary section, and a longer time where the work of two sections is done at one point, or where there is a large yard. For repairing frogs where there is considerable traffic duplicates of the frogs to be fixed are put in the track while the work is being done; but when the traffic is light, or there is not much work to be done, the frogs are taken from the track, repaired and replaced under the protection of flagmen. The proper adjustment of guard rails is looked after at the same time, and section tools are sharpened and repaired. It has been found that the life of frogs can be extended considerably by repairs given on the ground in this way. The cost for labor and material in repairing about 225 main track spring frogs has averaged about $3.75 each. The fact that these frogs have not needed to be shipped justifies the opinion that the plan of field repairs is an economical one; particularly when the economies effected in repairing switches, tools, hand cars, etc., by saving the trouble and delay of sending them away for repairs, are taken into account.—Railroad Gazette.

"The electro-gas signal does not now meet with the favor it enjoyed at first." Apparently, this careless sentence, whatever it may mean, is quite incorrect, and yet it appeared in this paper a few weeks ago. Having given a wrong impression to the reader, he may fairly expect a somewhat full statement of the facts. All the facts as to certainty of operation of the different forms of automatic signals are not available for publication, although they exist. Having been allowed to examine the official records of some of the railroads on this subject, a general statement, sufficient to show that the statement was quite wrong, can be made, although we are not permitted to give the full statistics. One railroad company with over 2,000 semaphore blades operated by Hall electro-gas machines, has a record of less than one signal mechanism failure in 1,300,000 blade movements. There has been no failure in which the signal has shown clear when it should show danger. On another railroad, with a large installation of Hall electro-gas signals, they report as a percentage of efficiency 99.98. Still another report shows no failure to clear, and only one failure to danger in more than 73,000 movements. The first installation on the Putnam division of the New York Central, 34 signals, has been in service about four years. It has a record of two years with no failure. Three failures were reported when the electric trains were put in service on the electric division. The heavy voltage current from the nearby electric zone lines temporarily interfered with the control of the relays at Van Cortlandt Park. This trouble was promptly corrected. It is interesting to note from the reports of different railroads that the tanks containing 50 pounds of liquid gas have averaged records varying from 7,600 to 8,000 movements per tank. We are told that it is considered good practice to remove the tanks before the pressure is reduced much below 200 pounds pressure. This does not cause loss of money, for the reason that the road pays only for the amount of recharging necessary to make a full 50 pounds. The cost of the gas is about 4 cents a pound. It seems wrong, after several years of use of different forms of automatic signals, that the information is not available for making comparisons of the cost of maintenance and operation. Standardizing the method of keeping these accounts would seem to be a function of the Railway Signal Association.—Railway Age Gazette.

TRADE NOTES AND FORMULÆ.

Fireproof Paint for Wood.—Mix 25 parts of ground heavy-spar, 1 part dry zinc white, 20 parts of water, and 25 parts of silicate of soda or water glass (give three coats).

To Weld Horn.—The two pieces of horn are moderately heated and the edges that are to be joined are carefully scraped to an exact fit. The horn pieces are then grasped with well heated pincers, the edges well warmed and quickly and forcibly pressed together. Polish with tripoli and water.

Isochrome Varnish for giving to colored copper plate engravings the appearance of oil-paintings: 250 parts of coarsely pulverized mastic and 125 parts of fine glass powder are mixed with 1,120 parts of oil of turpentine and allowed to stand 25 days, being frequently shaken in the interim. Thereupon 500 parts of Venice turpentine are added; it is allowed to stand a few days longer in the sun, and is then filtered.

To Repair Broken Plaster Casts.—*a*. Thoroughly mix 4 parts of plaster with 1 part of gum arabic and stir the mixture into enough water to make a thin paste. Apply this, in a thin layer, to the broken surfaces and press the joined pieces forcibly together for 24 hours. *b*. White lead 2 parts, powdered sugar 1 part, rubbed down together thoroughly, then made into a paste with a thick gum solution. This is applied to the surfaces of the fracture and the pieces are then firmly pressed together.

Permanent Paint for Cast Iron.—The articles are washed in dilute acid, allowed to dry, and the surfaces then gone over with a file, wire brush, etc., so that they are nice and smooth. They are then anointed several times with ordinary crude petroleum, and allowed to dry well between each application. The articles are then vigorously brushed with a stiff hair brush, which will impart to them a permanent brilliant appearance, in the case of stoves for instance. Subsequently a simple wiping with petroleum and brushing will suffice to insure a polish of increasing brilliance.

Pressed Ornaments of Veneered and Solid Wood.—(*a*.) Veneered ornaments: Pieces of wood of the length and breadth of the ornaments to be made are so cut that the long fibers run at right angles to the surface in which the ornament is to be pressed. The thickness of the wood must be according to the thickness of the relief and it must be perfectly dry. On the cross grain of the wood a veneer of any desired variety of wood is glued which either before or after gluing up has been soaked in oil, to prevent the penetration of moisture into the wood and to soften it. On the decorated metal piece, in which the pattern is engraved, the wood is laid with its veneered surface and pressed. (*b*.) Solid wood and pieces of any kind of wood, fibers, in the same manner, at right angles, etc.

Invert Sugar (Fruit Sugar).—Add to the water that serves for the solution of the sugar, per 1,000 parts, 5 parts of sulphuric acid, allowing the acid to flow into the water in a small stream and constantly stirring it. This fluid is run into a clean copper kettle and the sugar to be dissolved is added. The liquid is heated until it attains about 221 to 230 deg. F. and is then allowed to stand until it is cooled off to 158 to 140 deg. F. Through the action of the sulphuric acid, the cane sugar is converted into invert sugar and the sulphuric acid must now be separated from the solution. For this purpose, the finest pulverized white marble (waste from sculptors' workshops) is employed, as much being added to the hot fluid, stirring industriously in the meantime, as we used sulphuric acid (if we used 500 parts of sulphuric acid, we must use 500 parts of marble dust). The fluid effervesces actively during this process, for the marble dust (carbonate of lime) gives off carbonic acid and there is deposited when the fluid is quiescent a white precipitate of gypsum (sulphate of lime). The still cloudy fruit sugar solution is then run into the storage casks, where it generally clears completely while standing without any necessity for ultimate fining with albumen.

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